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Teaching Positions Wanted

ELECTRICAL ENGINEER WITH EXtensive international industrial experience wishes to enter teaching. Holds Professional Electrical Engineering Degree from major U. S. university. Experience in manufacturing, research, and power transmission installation, maintenance, and operation. Please direct inquiries to 51-15, *Journal of Engineering Education*, University of Illinois, Urbana, Illinois.

POSITION DESIRED. PROFESSOR of mechanical engineering (M.S. degree and reg. Prof. Engr.) wants administrative or teaching position in college, institute, or industry in which excellence of teaching is recognized as of first importance. Experienced in administrative and engineering work in industry and in university teaching. Experienced in industrial training and use of training aids. In conjunction with present teaching doing work in programmed learning (teaching machines). Resume on request. Write 51-14, *Journal of Engineering Education*, University of Illinois, Urbana, Illinois.

CIVIL ENGINEER—PH.D.—9 YEARS experience teaching and research in plain and reinforced concrete while getting degree. Seek change for Sept. '61 or '62. Write 51-13, *Journal of Engineering Education*, University of Illinois, Urbana, Illinois.

(*Continued on page 860*)

Do You Know

► That the Annual Meeting is at the University of Kentucky, June 26–30? The Blue Grass Country is ready to welcome you.

► That 348 academic degrees are currently conferred by the colleges of engineering in the United States? About 230 are offered by only one school each. This is reported in "Academic Degrees," by W. C. Fells and H. A. Haswell, U. S. Department of Health, Education and Welfare. No other field has so many! Next in order is education with 250 and then business with 175. Isn't this a horrible distinction for engineering to have? Isn't this a mess we ought to be able to straighten out? The 2,000 or more institutions reporting offer about 1600 different degrees. Order OE-54008, Bulletin 1960, No. 28, "Academic Degrees," from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., $1.00 per copy.

► That slowly but surely engineering departments are being more realistically designated? Rensselaer Polytechnic changes Metallurgical Engineering to Materials Engineering, and Aeronautical Engineering becomes Aeronautical Engineering and Astronautics. The former was done to recognize that work in nonmetallics will be included in the curriculum to achieve a well-rounded program. The latter was done because of the inclusion of programs in Space Technology.

► That the number of colleges and universities granting a degree in mining engineering has dropped from 34 to 29 in the past three years? Currently, there are 950 enrolled, and in 1960 there were 213 mining engineers graduated. Lehigh University is the latest to announce the discontinuance of a Department of Mining Engineering.

► That over 200 engineering teachers applied for the summer institute for engineering teachers offered by Penn State? This is the second year the institute is being offered. The applicants came from 105 different schools. Many will be disappointed, because the capacity of the institute is 70. The Ford Foundation supports the program by virtue of a grant to Penn State.

► That courses on the use of computers and the applications of computer methods are increasing rapidly in IE curricula? The 1961 Newsletter of the IE Division lists comments about course additions and ideas from 42 schools, and 15 mention courses in or applications of computer methods. Two other observable trends are an increased emphasis on reliability and an increase in mathematical requirements. In the "Letter From the Chairman," H. T. Amrine states, "One disturbing note pervaded our sessions, and that was the almost complete absence of members from industry. If we are to have a true forum, we must get industry's viewpoint and this can be achieved only by having members from industry present at our meetings. Thus, the Executive Committee would like to request each member of the Division to share this responsibility and to encourage members from industry to join ASEE and to attend our meetings."

► That it is not too late to make plans to attend the Annual Meeting? You won't be the only one who did not preregister.

► That the English Speaking Union will again sponsor an exchange of teachers in technical institutes in Great Britain and the United States? One exchange involving two people from each country will take place in the spring semester and another in the fall semester. Unlike the 1960 program, administrators are eligible in 1961. Participants spend 56 days studying technical institute education in the opposite country. The grant is sufficient to cover minimum expenses of travel and subsistence. Application forms are to be obtained from A. Ray Sims, Chairman, Technical Institute Division of ASEE, College of Technology, University of Houston, Houston 4, Texas.

► That the number of representatives from industry attending the meeting of the Southeastern Section has increased from 3 to 32 in four years? The Section has an active RWI Division under the chairmanship of Professor F. T. Carroll, Jr. of LSU. In addition to promoting attendance at the Annual Meeting of the Section, the RWI Division also is promoting membership among a list of 350 companies in the Section. Through the efforts of RWI two of the schools in the Section have had one-day meetings at which people from industries in the area are invited to the campus to meet with the dean and his faculty in order to become well acquainted personally and with each other's interests. Perhaps other Sections will want to follow this type of worthwhile activity.

► That the first Inter-American Congress on Chemical Engineering will be held at San Juan, Puerto Rico on October 23–28, 1961? It is hoped that all countries in South, Central, and North America will participate in the program intended to serve as an exchange of ideas, knowledge, and experiences contributing to the advancement of chemical engineering. The director of the Congress is Rafael Munoz, President of the Puerto Rico Institute of Chemical Engineers, P.O. Box 47, Rio Piedras Station, San Juan, Puerto Rico.

► That the First International Congress on Experimental Mechanics will be held on November 1–3, 1961, in New York City? The meeting is cosponsored by the Society for Experimental Stress Analysis, ONR, OSR, and the Applied Mechanics Division of the ASME. Somewhat related to this meeting is the International Symposium on Photoelasticity to be held on October 29–31, 1961, at the Illinois Institute of Technology. The Symposium is sponsored by the OOR, IIT, and SESA. What happened to ASEE and its Mechanics Division?

► That an International Measurement Conference will be held in Budapest June 25–July 1, 1961? Papers on theory and practice of instrument design or manufacture; instruments and methods for measuring geometrical, mechanical, thermal, physico-chemical, electrical, and magnetic quantities; and time frequency and radioactive radiation are among the topics on which papers will be presented. There also will be an international measurement and instrument show. Information regarding the conference can be obtained from Mr. Gyorgy Striker, Executive Secretary, IMEKO 1961, Budapest 5, POB. 3.

► That a Conference on Engineering Education and Industry sponsored by the Organization for European Economic Cooperation was held at Baden-Baden on April 10–13? The purpose of the Conference was to enable industrial, governmental, and educational authorities to discuss and compare the different national experiences in developing such cooperation and to formulate the general principles which, when adopted by policy makers, will further strengthen the industry-education partnership. The five basic papers presented for discussion are The Technician, The Professional Engineer, Further Engineering Education, The Training of Talented Individuals Already in Industry, and Industry's Contribution to Resources for Education. Four papers published in the JOURNAL OF ENGINEERING EDUCATION during the past two years were reproduced, translated into French, and distributed to attendees.

► That if you have never brought your family to the Annual Meeting you should decide to do so now? Let them also cultivate friendships at other institutions.

► That accumulated engineering literature for 1960 is now being compiled for dissemination on a world-wide basis in the *Engineering Index* for 1960? A trained staff of engineering linguists reviews each issue of over 1800 engineering and technical publications as they are issued each week or month. Last year they selected and annotated more than 34,000 articles covering 249 "field of interest" divisions of Engineering. The articles were published in 44 countries

and in more than 20 languages. Each annotation is supplied on a 3 × 5-inch library card, there being sufficient information for the reader to decide whether the article is of interest. If the article is not available in a local library a photostat or microfilm copy of the entire article can be ordered from *Engineering Index;* the publications are kept on file indefinitely in the Engineering Societies Library in New York. If you wish to get a current catalog, without charge, write to the *Engineering Index*, 29 West 39th St., New York 18, New York.

► That an interesting series of publications on higher education in the U. S. are available from the Institute of International Education? Those within and outside of educational institutions working with students from abroad who wish to study in the U. S. will find the booklets helpful. The newest on the list is the *Land-Grant College and State University in the U. S. A.* The others are: *The Liberal Arts College in the U. S. A., Graduate Study in the United States,* and *The Two-Year College in the U. S. A.* All are available from IIE at 1 East 67th Street, New York 21, New York, for 15¢ per copy.

► That the AAAS has a man on its staff whose only function is "improving public understanding of science?" AAAS also has a section on engineering of which C. E. Davies of the United Engineering Center Project in New York and L. K. Wheelock, Secretary of Engineers Joint Council, are Chairman and Secretary, respectively. The member-at-large from engineering who is on the Section Committee is R. Karl Honoman of Bell Telephone Laboratories. For the year, $624,833 were received in grants for special studies. The income of the AAAS, other than from grants, was $1,388,000, which exceeded expenditures by about $150,000. It is interesting to note that this income is approximately 10 times that of ASEE.

► That there is a rumor that a moonshiner's still will be on exhibit at the Annual Meeting? The Internal Revenue Service, however, has not yet given permission for operation.

► That in order to improve the reading abilities of adults the "National Reading Research Foundation" (NRRF) has been chartered? Speed-reading training workshops throughout the country are to be conducted. Funds realized from the programs will be used to support badly needed research on the sociology and psychology of reading. It is estimated that 15%, or 2.3 million of the school children are 2 or 3 grades behind in ability. The average adult is only 20% to 40% efficient in reading skill! It is claimed that only 17% of American adults read any books at all, as compared to 34% in Australia and 51% in England. Lastly, a 1956 Gallup Poll showed that 26% of the country's college graduates had not read a single book in the preceding year! Temporary headquarters of the NRRF is 1105 East Ohio Building, Case Institute of Technology, Cleveland 6, Ohio.

► That industrial managers feel that companies are doing more to advance professionalism than engineers give them credit for? One out of four engineers believe they are thought of as second-class professionals, but no industrial managers agree with them; 61% of the engineers think there is considerable malutilization of engineers, but only 30% of industrial managers agree; more than half the engineers in industry think that higher pay would advance the engineering profession, but only 20% of industrial managers agree; 90% of the managers rated engineers among the most valuable employees, but only 52% of the engineers felt that they are so regarded. The report, prepared by the Opinion Research Corporation for the Professional Engineers Conference Board for Industry, in cooperation with the National Society of Professional Engineers, concludes, "Many of these programs and policies are not now getting through to engineers if companies are doing all the things they say they are." Copies may be obtained from the Professional Engineers Conference Board for Industry, 2029 K

Street, N.W., Washington 6, D. C. for $2.00 per copy for members of NSPE or $4.00 for non-members.

► That one of the statements made about the observations of EJC's team visiting the USSR, Feb. 1961 JOURNAL, is not entirely correct? Dr. W. E. Lobo, Chairman of the group submits the following correction. "It is the present plan, or goal, that of those admitted to full-time, i.e. daytime, attendance at the schools of higher education, not over 20% may come directly from the secondary schools. The remaining 80% are first to spend two years in industry before being permitted to continue their education." Apologies are extended.

► That *Effective College Recruiting* is a book published in April? Questionnaires and interviews with more than 100 company recruiters and several hundred University of Michigan business students are included in the study. In addition, 135 recruiting brochures were analyzed. The results seem to be that although business men preach the gospel of free enterprise on a speaker's platform they are loathe to mention it in their college recruiting brochures. Dr. G. S. Odiorne, Director of the Bureau of Industrial Relations, states, "With the exception of a few public accounting firms, you could read all these brochures and never get an inkling that the company expected a good day's work," and "Despite emphasis on opportunities to rise, there was little mention that people should expect to shoulder heavy responsibility as the price for success."

► That ASEE membership has reached 10,000 for the first time in history? Come to the Annual Meeting to help celebrate the occasion.

► That college and university libraries are facing some real problems? Since the strength of the library is a reliable gauge for measuring the excellence of the total program of higher education in a given institution, it is well that everyone give occasional consideration to engineering libraries. Size is important, but adequate service is still more important. How the collection is housed and used and the administrative competence of the professional staff make a difference in quality. Not only are the libraries confronted with the problem of more books they also must meet the increased space needs of the larger faculties and student bodies to come during the next 10 years. The medium expenditure for university and college library service at the present time is approximately $43 a year for each student enrolled, but institutions known for the strength of their libraries budget several times that amount. Any future budgeting merely to maintain already established libraries will be inadequate. These are some of the ideas gleaned from "Wake Up and Read," No. 20 in a series of leaflets on the nature and needs of higher education in the U. S. prepared by the Council for Financial Aid to Education, Inc., 6 East 45th St., New York 17, N. Y., 15¢ per copy.

► That a "National Committee for Fluid Mechanics Films" has been organized? The members are A. E. Bryson, Donald Coles, Stanley Corrsin, S. J. Kline, Hunter Rouse, A. H. Shapiro, Chm., and Hsuan Yeh. The purpose of the committee is to bring into being a series of films for instructional purposes in Fluid Mechanics. A proposal for financial support will be prepared and a request for funds will be made to a foundation. One film, "The Fluid Dynamics of Drag," already is in existence and a second, "Vorticity," is nearly completed. Correspondence in regard to the work of the committee should be directed to A. H. Shapiro at MIT.

► That this ends another year for DYK? You are getting a big dose this month and if you got this far your patience is appreciated.

W. LEIGHTON COLLINS
Secretary

More Effective Engineering Faculty Utilization

ALVIN C. EURICH

Vice President and Director, The Fund for the Advancement of Education and Executive Director, Education Division, Ford Foundation

More than anyone else in our society, engineers and scientists have contributed the tools which have completely revolutionized modern communication. Their ingenuity has made possible motion pictures, film strips, slides, records and phonographs, radios, magnetic tape, micro-film, teaching machines, computers, and color television. With the likely addition of the third dimension, television may soon reach the ultimate in its power to transmit realistically the human personality and other natural resources for learning. Further advances in satellite design seem likely to extend the effectiveness of mass communication. Our devices will transmit more information with greater impact, will reach more persons over farther distances more quickly than ever before.

The engineer's inventiveness has brought about not only new tools, but also new types of analyses which have increased the efficiency of our industrial, agricultural, and administrative processes. Time and motion studies and quality control, now regarded as fundamental for many of our operations, are but a few examples.

But curiously, after contributing all of these important new inventions, the engineers have left largely to others the purposes for which these should be used. With few exceptions, they have not even bothered to use them for their own needs to communicate: specifically, for the teaching of engineering students. And yet, education is clearly a process of communication, whether its setting is the engineering college, the research laboratory or the job. Logically speaking, it also demands the efficient use of available teachers to transmit whatever they have to say to students. Given this gap between the invention of the tool and its use to further education, the question of better utilization of engineering faculty takes on added significance.

There is every reason to believe that the thoughtful application of engineering techniques would result in greatly improved education for our youth. Certainly the tremendous strides made in other areas amply justify such hope. Technology applied to agriculture, for example, has reduced the percentage of gainfully employed people required to raise our food by 10% every 20 years, from almost 38% in 1900 to 8% in 1960. At this rate, our agriculture should be carried on wholly by automation in another 20 years!

In industry, the applications of technology to produce more goods per man-hour are so numerous that the horizons are without limit. Because of these developments we passed a major milestone only a few years ago when for the first time in any country's history the number of "white-collar" workers outnumbered those in "blue-collar" jobs. This trend will almost certainly accelerate in the years ahead.

In medicine, innovation means that 90% of the drugs prescribed today were wholly unknown just 20 years ago, in 1940. And in this same period, our average life expectancy has risen by 7 years.

Abstract of an address at the Mid-winter Conference for Research on Engineering Faculty Utilization held at the Westinghouse Educational Center under the auspices of the American Society for Engineering Education, Pittsburgh, Pennsylvania, January 9, 1961.

Such progress has not occurred by chance. Rather, it has come about through recognition of critical problems and the flexible use of new knowledge in the search for their solution. In this connnection the Stanford Research Institute immediately comes to mind because I was so deeply involved in setting it up some years ago. The Institute was established because several industrial leaders, notably Atholl McBean, and some of us at Stanford University were aware that major problems in industry and in government, such as the use of water and the control of smog, needed the full-time attention of a highly competent technical staff. After borrowing several hundred thousand dollars, we engaged Jesse Hobson as Director. He brought together the team that tackled the problems. Now, only 13 years later, the Institute conducts a total volume of research running more than $25 million yearly with a staff of 3,000 people. It has pioneered in combining economic analysis with technical work. In order to bring about more efficient operation, it has developed new products, set up new industrial plants and relocated old ones. To name only a few more of its outstanding accomplishments, it designed and built the computer for the Bank of America; discovered that the automobile, not the refinery, was the major offender in the creation of smog; and worked out development plans for such diverse areas as Indian tribes, large urban districts, the Hawaiian Islands, Italy, and various countries in South and Central America and Asia. Furthermore, out of this whole enterprise, in slightly more than a decade, have come an impressive number of people who have founded their own businesses or are now senior executives in major corporations scattered throughout the country.

What, you may wonder, has all this to do with faculty utilization? I am simply suggesting that we take careful note of the progress made through technology in agriculture, industry and medicine. Or, from another angle, that we observe the success of an approach such as the Stanford Research Institute's where a highly competent technical staff is brought together to apply its skills to finding new answers to recurring problems. And I am suggesting further that this general approach is equally applicable to education (including that of engineers)—that education requires the same degree of full-time attention from an intelligent, technically competent staff.

Given the outstanding success of the engineering approach to solving other problems, it is surprising how little it has been tried out in education. Over the years, education stands virtually alone with its major problems unsolved, hardly touched by those advances in technology, invention and efficiency that have transformed modern life. And yet the crucial problem of education at all levels—the quantitative and qualitative shortage of teachers—is also central to the instruction of engineers.

The shortage of engineering teachers is especially disturbing because of competition for the same people from nonacademic fields. Only for engineers and scientists does the Sunday *New York Times* print separate pages of want ads —an average of about 12 full pages a week, 624 per year! Recruiters flood the campuses to sign up new engineering seniors even before they have their degrees and the beginning salaries offered are generally above those which other college graduates receive.

But even though engineering were able to attract a larger number of students and faculty, this would still not meet a more important aspect of demand —that generated by the growth and complexity of new knowledge in new industries such as electronics, missiles, nucleonics, chemistry and drugs. As Frederick Terman has said, "The speed with which the orientation will shift toward fundamentals in engineering and science will be limited only by the inertia of existing faculties and by the existing organizational structures in educational institutions."

We are slow to change education. Over and over again, fixed formulas, such as small class size, hamper innovation. Engineering in other fields follows the general theme of *doing more, doing it better, and with fewer people.* In edu-

cation, on the other hand, the traditional theme for improvement seems to be doing *less* per person. The ideal is Mark Hopkins on one end of a log, a student on the other. But what President James A. Garfield actually said was:

"If I could be taken into boyhood days and had all the libraries and apparatus of a university with ordinary routine professors offered me on the one hand and on the other a great, luminous, rich-souled man, such as Dr. Hopkins was twenty years ago, in a tent in the woods alone, I should say give me Dr. Hopkins for my college course rather than any university with only routine professors."

We need now to apply the engineering formula to education.

Signs of Progress

Recently there have been signs of progress. Under the pressure of growing faculty shortages and mounting enrollments, efforts are underway to improve the utilization of engineering faculty. It might be useful at this point to summarize some of the results to date as I see them.

1. *Class size.* Experiments have been carried out at Rensselaer, the University of Kentucky, Washington State University, Texas A. & M. In general, the results indicate that students learn as much or more in large classes as in small ones but that faculty members prefer small classes.

2. *Television.* Experiments have been conducted at Case, Purdue, the University of Akron, the University of Illinois, the University of Minnesota and Pennsylvania State University. Again, in general, students learn as well with televised instruction as in regular classes, but faculty members tend to prefer the conventional teaching methods.

3. *Independent study.* Although no experiments in engineering education have focussed primarily on this approach to better utilization of faculty, Purdue and the University of Akron have combined televised instruction with planned increases in independent study. Rensselaer combined changes in class size with more independent work. The results are consistent with those found in other fields showing that the student learns more when he is given greater responsibility for doing so. In addition, there is a distinct advantage in the faculty time saved.

4. *Assistants and aides.* Experiments at Akron, Brown, Rensselaer and the University of Kentucky have resulted in the better use of the professional competence of scarce senior faculty. Student assistants were widely used in these experiments with profit to their own learning as well as to the students being taught. Very often this experience unexpectedly stimulated the young engineers to enter the teaching profession.

5. *Teaching machines and programmed learning.* Teaching machines of various sorts are being tried out in some engineering courses. Industry is also using them for the technical training of employees. A programmed text, *The Arithmetic of Computers,* has just been published for self-instruction.

Experiments with programmed instruction at various grade levels show consistently that students learn more in less time. One authority says he now has evidence showing that students learn twice as much in the same amount of time. A more conservative estimate comes from a Hamilton College experiment in teaching logic with mechanical aids and programmed lessons: "We suspect that there is close to a 50% increase in overall efficiency."

These results, together with industry's continuing use of such devices in its employee training programs, suggest that the use of programmed learning will yield equally good returns in formal engineering education.

In all of these new procedures for better utilization, it is clear that there is no loss in learning. The net results, on the contrary, show a distinct gain in the amount learned, in the saving of student and faculty time, in the earlier development of student independence and initiative, in the recruitment of young engineers to the teaching profession and in the exposure of more students to top teachers.

And still, education resists change. Traditional modes of instruction are ac-

cepted on faith, but we insist on evidence and proof concerning the new procedures such as we have never demanded for the old. Innovations are viewed with suspicion and approached with demands for unattainable rigor. For educational processes, however, whether experimental or traditional, it is virtually impossible to attain the kind of proof that is demanded in the physical sciences because: (1) our objectives are less clear; (2) our measuring devices are crude; and (3) the multitude of human variables can neither be defined nor fully controlled. This inherent ambiguity is still no reason to reject what we do know on a practical level. We can reasonably ask whether students learn as much or more under new conditions as under old, as measured by our present crude means of observation, and can abide by the answers. On these grounds, and on the basis of evidence that has accumulated, we can have greater faith in new tools and new arrangements for learning than we can have in traditional practices.

Obviously there is no magic device, gadget, or arrangement that will solve all our educational problems. We need to bring together all our resources for learning in the combinations most effective for given situations. If we could achieve the integrally balanced arrangement of all the components of a learning situation in the same way that we have achieved the balance advertised in stereophonic high fidelity systems, for example, our students would undoubtedly learn a great deal more in much less time. The fact that we have not yet attained this level in education is no reason not to seek it continually.

It is equally clear that we cannot get final answers through research at this time on the effectiveness of class size, television or motion pictures, independent study, human aides, or other devices. What, then, are we groping for when we deal with the problem of better faculty utilization? What are the questions for which we must find answers now?

Some Possible Answers

Foremost, we must solve the problem of the acute shortage of able teachers. We know now that not enough highly qualified people will be available to teach the number of students we will soon have in our engineering schools—in fact, in any part of our educational system. And because the quantitative problem is insoluble, and perhaps not even as important as the question of excellence, we must adopt the attitude that we *want* to find ways of doing a better job with fewer people. The creative imagination, energy and technical competence that have been displayed in our industrial and scientific growth as a nation must now be applied to education. This is basically a question of "engineering" the teaching situation.

But to transform such aspirations into educational accomplishments, we must devise a machinery for change. And in order to make this effective, it must function at every level: federal, state, local and institutional. We need groups in education that are devoting full time to innovation.

Last June I suggested to the Governors at their meeting at Glacier National Park that each state set up a Commission on Educational Development. It would be the task of this Commission to look constantly to the future and to devote its entire attention to the improvement of education in the state. Obviously, such Commissions could not follow a uniform pattern; their organization would vary from state to state. But in every case, these Commissions should create an atmosphere in education which is comparable to that in agriculture, industry or medicine and says: "Each year we can and will do the job better." The membership of such a Commission should be of the highest caliber, comparable to the members on the Board of Regents or Trustees of the state university, and it should work with a highly qualified staff. The Commission would have no administrative responsibilities.

It would serve primarily four functions:

(1) It would sponsor new experiments designed to provide higher quality education with due regard for efficiency and economy;

(2) It would disseminate information about new developments not only

within the state but throughout the country;

(3) It would promote the adoption of such new developments as have been tried and found successful; and

(4) It would issue an annual report and recommend necessary legislation.

The Commission on Education Development should be financed on the basis of a fixed percentage of the state's budget for education—at something of the magnitude of 0.5%, to start with. From such an appropriation, it should be authorized to make grants to educational institutions for experiments designed to improve educational methods.

Such Commissions could be supplemented with a federal and with local institutional Commissions. They could render the same services to education that agricultural research stations have rendered to agriculture, that research and development groups have rendered to industrial growth, and that health institutes and pharmaceutical research have rendered to medicine. Together they would create in education an atmosphere that seeks new and better answers.

Perhaps one of the best ways for getting such a movement underway would be for each engineering school to set up a development group concerned wholly with the improvement of instructional procedures, with doing more and better teaching with a larger student-teacher ratio. Once developed this could become a new field for engineers comparable to industrial management engineering. The procedures devised in the engineering schools could be extended to other colleges and universities—indeed, to the entire educational system. Through such a concerted effort we would learn how with the tools at hand we could make much better use of our professional competence in teaching.

For after all, the total effort in education must be concerned with the intelligent utilization of our teachers and any new means of communication that may enhance learning. We have ample resources—human, natural and financial—to effect vast improvement in our educational program and to make its progress commensurate with other areas of our society. In this fast-moving world, our orthodox procedures in education are inadequate. Antiquated techniques, antiquated customs and concepts have acquired a sanctity much beyond their merit. They must be desanctified, unfrozen, re-examined, revitalized. We must encourage a creative, restless, and positive concern for improving the quality of education so that each individual in this democratic society can become all that he is capable of being. In view of our resources for more effective and efficient communication, this is basically a problem for engineers. If they demonstrated how the new tools which they have given us can best be used in education, they could help modernize our whole educational system.

MATERIALS SCIENCE AT CINCINNATI

The department of chemical and metallurgical engineering at the University of Cincinnati has announced a new area in which graduate students in the department can major. This area will be known as materials science. Work leading to both the master of science and doctoral degrees is offered.

The university's new advanced studies are a direct outgrowth of pressing national needs for new materials of many types, according to Dr. William Licht, professor and head of the department. Cincinnati is among the first universities in the country to offer such a program. Other institutions introducing it include: Northwestern, Stanford, and Cornell universities, he said. The program will be under the chairmanship of Dr. Michael Hoch, Cincinnati University professor of metallurgical engineering. Students can enter the program from undergraduate backgrounds in either engineering or chemistry and physics.

Engineering Manpower and Public Attitude

S. B. INGRAM

Chairman, Engineering Manpower Commission of Engineers Joint Council

The problem of providing an adequate supply of trained technical manpower to staff our increasingly complex technological civilization is one of the central problems of our time. For more than a decade we have experienced a persistent shortage of engineering and scientific personnel. There are sound reasons for thinking that this shortage may be a continuing phenomenon and, in fact, may be expected to become progressively more acute in the future. A brief recounting of the history of the engineering manpower problem and of the public attitude toward it is of interest.

Between World War II and the Korean War, the technological labor force seemed fully capable of satisfying the demands made upon it. Defense activity was only moderate under postwar military retrenchment, but engineering employment steadily increased under the influence of an expanding civilian economy. Additions to the engineering labor force were substantial as a result of a high level of college enrollment accentuated by the GI bulge. The prevailing public view of this period, shared by many in authoritative and official positions, was that there was a surplus of engineers either already in existence or at least impending.

With the advent of the Korean War in 1950, military production contracts were sharply increased, and military research and development activity became greatly emphasized and carried on at an accelerated pace. This military activity with its resultant demand for technical manpower was superimposed on a continuing high level of civilian business activity. In the following years the rate of engineering college graduations decreased. This decrease was a result of two factors: the natural tapering off of the GI bulge following its peak in 1950, and the turning away of college freshmen from the engineering schools as a result of the widely held view that the engineering profession might actually become overcrowded. The net result of these conditions was to develop a near panic market for engineering talent in 1950, which basically has not altered in character more than ten years later.

The public attitude of the 1950's was one of reorientation and adjustment to a market condition which was just the opposite of what the public had come to expect. In the early years of the decade the shortage of engineers and scientists received wide recognition and was the subject of much discussion. We in the Engineers Joint Council set up the Engineering Manpower Commission. The important point to note in public attitude in this period was that little attention was given to the long-range aspects of the problem. Public attitudes do not change readily, and the postwar concept of a surplus of engineers persisted in the form that the immediate shortage, which could not be denied, was conceived of as temporary. The shortage was linked in the public mind with transient conditions in the economy, specifically with the Korean War and the high level of military expenditures in the Federal budget.

Korea came and went, and was replaced by the cold war and the military and technological competition with Russia. The shortage continues, but I think it is fair to say that in the public mind it is still regarded as temporary and dependent on "abnormal" factors in the economy which if not present would per-

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mit the "normal" condition of an excess of trained technical talent to re-establish itself.

A Look at the Future

Is this right? Is the growing demand for engineers and scientists dependent on the military character of our technology, or is it determined rather by its complexity? And is civilian technology in this day of automation, synthetic materials, depletion of natural resources, jet transportation which practically eliminates distance, and communication which eliminates both distance and time, really less complex than military technology? Even space technology with its application to communications, weather forecasting, and navigation, is by no means a military monopoly. Should we not therefore look more deeply at the basic nature of our technical manpower shortage? What does the future hold?

First, what can we expect in the next decade? I have hinted that given full utilization of a civilian economy, it is quite possible that we might find our need for engineers and scientists as great as ever. In any case, the question of whether this is true or not appears to be academic for at least the next decade because a continuing large military budget and technological competition with Russia seem to be two things which are about as predictable as anything can be. Since there is no change in the trend to a more sophisticated development of our technology, military or civilian, it is reasonable to anticipate a continuing need to expand our technological labor force at a rate at least as great and probably greater than that which has prevailed in recent years.

On the other side of the equation, we come up against our ability to increase the size of this segment of the labor force at a rate commensurate with our needs. Here we find a fundamental limitation. I have tried to show elsewhere [1] that we can realistically count on graduating as engineers only about 2% of the group reaching college graduation age in a given year. I will not repeat the argument here in detail. It is based on only three assumptions: 1) that, in general, only those with an intelligence level represented by an IQ of 120 or greater are capable of completing an engineering training, 2) that three-quarters of the male portion of this group will continue for good reasons to enter other professional and academic fields, including science, and 3) that we cannot count on the female portion of the group to contribute to our supply of engineers in numbers sufficient to change the gross statistical picture. At the present time, the number of young people reaching age 22 each year is 2,300,000, and 2% works out to 46,000 as compared with the 38,000 engineers we graduated last year. Fortunately, the population of this age group will be increased by about 50% by 1970 as a result of the high birth rate of the late 1940's, so we can reasonably look forward to a modest increase in our rate of additions to the engineering labor force during the next decade. It appears to be a conservative prediction that in the 1960's we will witness a race between increasing requirements for engineering graduates and our slowly growing capacity to produce them, and that no basic change in the market conditions of the 1950's can be anticipated.

How about the more distant future? Is it possible to look farther ahead than a decade? An attempt has, in fact, been made in the studies carried out at the California Institute of Technology by Professors Brown, Bonner, and Weir, and published a few years ago in their book, *The Next Hundred Years*.[2] In a recent paper [3] Professor Weir specifically considered the technical manpower aspects of the long-range future. He made his considerations on a global basis, taking as premises the population explosion, de-

[1] S. B. Ingram, "Education for the Age of Technology," *Journal of Engineering Education*, Vol. 50, pp. 159–165, Nov. 1959.

[2] Harrison Brown, James Bonner, and John Weir, *The Next Hundred Years*, Viking Press, New York City, 1957.

[3] John Weir, "Technical Manpower for the Next Hundred Years," *Electrical Engineering*, Vol. 80, No. 5, pp. 338–340, May, 1961.

pletion of natural resources, exhaustion of energy sources and the necessity for developing new ones, the need to improve methods of agriculture to provide food supplies for the world's growing population, and the need to provide technical aid to underdeveloped countries. All of these factors create problems which can be successfully attacked only by the application of advanced technological methods. You will note that no assumption is made with respect to the magnitude of the world's military effort or even of the existence of technological competition between highly developed nations. The technological race is paced by the rates of population growth and of the depletion of energy sources and material resources. These long-range conclusions, though extremely general in nature, are nevertheless logical deductions from established facts and basic premises with which it is difficult to disagree. One is led to the conclusion that the needs for trained engineering and scientific manpower will grow continuously and will ultimately become the limiting factor in the world's ability to cope with its problem of maintaining an adequate standard of living for its expanding population, or, in fact, of merely sustaining life for it.

Viewed in this perspective, we arrive at the concept that the engineering and scientific manpower shortage we experienced in the 1950's and which seems likely to remain with us in the 1960's is only the first manifestation of a symptom which is characteristic of a highly complex technological civilization, and which will continue to become more pronounced as the complexity increases. It is important that there be a much wider public appreciation of this concept. If such an appreciation did exist, we would be much more likely to take constructive and realistic action to deal with some of today's problems as well as others which will arise in the future.

The Contribution of EJC–EMC

Now what can EJC and EMC do about this? EJC is the recognized spokesman of the engineering profession in the eyes of government and of the public. It is the specific charge of the Engineering Manpower Commission to:

1. Aid in establishing the importance of engineering to the national economy.
2. Aid in maintaining an adequate supply of engineers.
3. Promote the most effective utilization of engineers in support of the national health, safety and interest.

In the 10 years that EMC has existed, it has performed a valuable service to the nation and to the profession. I doubt if at the time of its inception its founders were much concerned with the distant future. The problems of the Korean War and its disturbing consequences were urgent and demanded immediate action. Programs were initiated; action was taken. Later they were expanded as the needs of the day required. All of this has been good and useful, but I think the time has come for us too in EMC to be looking farther ahead. Now, after gaining 10 years of experience, achieving a degree of leadership in the field, and, I hope, winning the confidence of government and industry, it is perhaps a good time for us to be reappraising our program and our function in terms of the long view. The engineering manpower problems of the future are full of challenge. They call for a bold and imaginative approach. If we in EJC and EMC can aid in their solution we will have made a notable contribution to the national welfare.

PROCEEDINGS WANTED

A copy of Volume 63 (1955–56) of the *Proceedings* of ASEE is wanted by the U. S. Army Engineer Waterways Experiment Station to replace a volume destroyed in a fire. Since extra copies of this particular volume are not available, anyone wishing to contribute a volume should send it to the Secretary of ASEE, University of Illinois, Urbana, Illinois.

Colloquium on Recruitment to Higher Technological Education

ERIC A. WALKER

President American Society for Engineering Education and President, The Pennsylvania State University

On March 10, 11, and 12, I attended a conference in England held to review problems related to the recruitment of British youth to "higher technological education." Actually, this was an exploratory conference, designed to isolate the major problems in this area for further detailed study. The conference, held under the sponsorship of the Department of Education of Oxford University, which is to conduct the study, was at Missenden Abbey (an English version of Arden House) some 40 miles north of London. Mr. A. D. C. Peterson, Director of the Department of Education, conducted the conference. Both the conference and the study that is to follow (as well as the participation in the conference of your president) were made possible by a grant by ASEE's own Eugene Rietzke, President of the Capital Radio Engineering Institute in Washington.

It was comforting to discover that the British have almost the same problems and the same lack of ready answers as we have here in America. It took us some time to arrive at a suitable set of definitions, since a good deal of confusion was caused early in the conference by the different meanings attributed by those participating to such words as "pure science," "applied science," "engineering," and "technology." One of the first problems, in fact, arose from the belief held by many of those attending the conference that the better men were going into "pure science," while those who were less good were going into "engineering." This led me to decide that, by "pure science," they meant research, the purpose of which is to discover how the laws of nature work. By "engineering," I found out, they meant the application of those laws to build machines and systems to satisfy the wants of mankind. From this, it was concluded that the engineer, since he has to have all the curiosity and knowledge possessed by the scientist but ought to be able, in addition, to synthesize this knowledge, is probably in shorter supply than the "pure scientist."

To understand the heart of the problem in Britain, it is necessary to know something about the British "system" of education. Actually, this British system is even less systematic than is ours here in America and admits (or submits) even less well to generalized statements. Education is compulsory for all British youngsters up through age 15, but they may attend school at government expense until they reach 19. Upon completion of his elementary-school program at about age 11, the pupil takes the "11+" examination and, on the basis of the results of this test, is assigned to a secondary "grammar," "technical," or "modern" school. About three-fourths of these 11-year-olds are assigned to the modern secondary schools, which, for all practical purposes, closes the door for them to the possibility of entering a university. These schools are designed to provide much the same sort of function as is provided by the American comprehensive high school, with the exception that the program aims almost not at all at university preparation. Most of the pupils assigned to these schools drop out of school as they reach 15.

Most of the top one-fourth of the pupils are assigned to the secondary grammar schools, the rest being assigned to the technical schools . These latter were designed to provide pretty much the same function that is provided by

the American vocational high school, but they are becoming more like the grammar schools all the time, despite a continuing bias toward scientific and practical studies.

The grammar schools are definitely university-preparatory institutions. The curriculum "tapers from a broad base to a comparatively narrow platform." During the first three years (up through age 14), the program is general and diagnostic. The program typically includes instruction in English, history, geography, French, mathematics, science, art, music, religious studies, and handicrafts. Latin is usually added in the second year. During the last 2 years of the "regular" 5-year secondary program, some electives are permitted, and there is some specialization to permit the student to concentrate more of his time on mathematics, science, languages, or literature. Many of these students take an introduction to calculus and co-ordinate geometry. At the end of this period, practically all pupils take the General Certificate of Education (GCE) examination at the "ordinary" (0) level, although there is a growing tendency for those definitely "scheduled" for university work to skip this examination, that is, to be promoted without it.

Today, about 40% of the grammar-school students (or about 10% of those who took the 11+ exam) go on to the sixth form. Administratively, the sixth form is a part of the secondary school, and corresponds roughly to the 13th and 14th years of the American high school or to the American junior college. It is generally looked upon as the "concluding stage of secondary education." For the most part, the program is definitely aimed at university preparation; but, because of its increasing popularity, there is a growing tendency to introduce "something of a technical bias . . . on practical subjects" into the curriculum. The curriculum remains, however, "markedly specialist in character," and about two-thirds of the student's time is spent, characteristically, on 3 subjects. Typical groupings of these 3 subjects include mathematics, chemistry, and physics; Latin, French and German; English, history, and geography; applied mathematics, pure mathematics, and physics; and physics, chemistry, and biology. The programs tend to divide into 2 classes: the sciences (about 60% of the boys) and the arts (about 40%).

At the conclusion of this program (and there is a mortality of about 50% each year), the students take the "advanced" (A) level GCE. The order of popularity of specialization, as shown by the number of students taking the advanced GCE in the various subjects, is mathematics, physics, chemistry, English, history, French, biology, geography, and Latin. The results of the scores on the advanced GCE are used, along with the institutions' own requirements, for determining admission to the universities, the teachers' colleges, the technical colleges, and to certain professions directly. About 6% of the British youngsters attend the "public" (i.e., private) schools, and about 30% of these are eventually admitted to the universities.

Mortality becomes high after the end of the compulsory-attendance period has been reached. About 42% of the British boys and girls attend school full-time during their 15th year; during the 16th year, the percentage drops to about 25; and, during the 17th year, to only 12. Actually, only about 20% of those who started in the public schools get into the grammar schools, 6% complete the sixth form to qualify for university admission, and perhaps 5% are actually admitted.

The student spends only 3 years at the university, which gives him, in conjunction with the sixth form, a 5-year program of education beyond his 12 years in elementary and secondary schools. Each year is divided into 3 terms, each of which is 8 weeks in length. At the British universities, the students are not required to attend classes or to take periodic subject-matter examinations to the same extent as the American students. However, at certain universities they are required to spend a certain amount of time each week with their tutors. A very high percentage of those who enter the universities are eventually awarded their degrees, and the first year is not used as a trial period, as it is in

our universities. During the university program, the student takes almost no work in what we call the "socio-humanistic stem." In fact, considering the specialization associated with the sixth form, the British student takes almost no "general" or "cultural" courses beyond the first part of his regular secondary grammar-school program. In the universities, the "honours" programs have, in the past, been associated with a high degree of specialization, which, in turn, has been associated with "pure science." On the other hand, the "ordinary" programs have been associated with a broader education, and this has been associated with "technology." This has led to a certain amount of academic snobbery and prestige that has worked to the disadvantage of engineering, and there is some agitation to change the terminology designating the 2 types of programs.

Education at a university, however, is not the only avenue by which a young Englishman can obtain a university degree. Many colleges in England have working arrangements with universities through which their students can be awarded degrees by the university upon the completion of their studies. Further, the University of London awards what it calls "external" degrees to anyone who applies, meets certain requirements, and satisfactorily completes an examination.

Nor is the university degree the only avenue to professional recognition. In fact, only about one-third of the professional members of the British engineering institutions (comparable to our founder societies) hold university degrees. In England, there is a wide variety of colleges of advanced technology (such as Northampton and Loughborough), technical colleges and institutes, and "national" colleges (e.g., College of Aeronautics). These institutions prepare students for the Diploma of Technology (established only in 1958), the Higher National Diploma (HND—for full-time work at a technical college or institute), the Higher National Certificate (HNC—for part-time work), or for diplomas issued by the institution itself.

This reference to part-time study needs some further explanation. "Student apprenticeships" are, in England, the backbone of the nonuniversity system of technological education. Through these apprenticeships, most of the technical-college students receive financial support, practical industrial and plant experience, and formal training. These apprenticeships usually take one of 2 forms. In the first of these, boys are recruited at 16 (before the sixth form) to take evening and/or day-release courses at a technical college or institute in order to qualify for an HNC, which seems to be roughly equivalent to 3 years toward an American baccalaureate degree. In the second, the boys are recruited after the sixth form at 17 or 18 for a "sandwich" course, which is similar to the American co-operative program in which a student alternates periods of work with periods of study. This program leads to the HND. This system of apprenticeship combined with part-time studies at a technical college or institute is a common and characteristic path to engineering in England. At the national colleges, these apprenticeships receive the sanction of the central government and evidently provide all the student body. Among the advantages cited for this type of program is the practical training the student receives. There is, however, considerable debate about how much work should be done in the shops in forging, turning, fitting, etc., and how much time should be given to drafting.

In fact, there are even some "university apprenticeships." These apprenticeships provide a mechanism by which an employer finances the university education of a prospective future employee. The British Petroleum Company's program is typical. "The Company recruits selected young men who have completed their National Service and seconds them for a normal academic course, to selected Universities to graduate in various technologies. The course takes up to four years and appropriate practical experience is provided during vacations. University fees are paid by the Company, in addition to salary of £350 p.a. Candidates must possess a G.C.E. with at least English Language and a foreign language at "O" level and good "A"

levels in Mathematics, Physics, and Chemistry or, in some cases, Pure Mathematics, Applied Mathematics, and Physics. . . ." Some companies insist on a year with the company before the start of the university work and a year following it, rather than using vacations for the "practical experience."

There is still another avenue to professional recognition in engineering in England. Although there is no system of licensing in England and no equivalent for our ECPD, EJC, or, for that matter, ASEE, there are organizations that are equivalent to our founder societies. These professional "institutions"—the British Institution of Radio Engineers, the Royal Aeronautical Society, the Institution of Naval Architects, etc.—have rigorous requirements for the different "degrees" of membership. For associate membership in the Institution of Civil Engineers, for instance, the applicant must pass "a written and oral examination (from which a university degree in engineering secures partial but not complete exemption) supported both by evidence of approved practical training and experience extending over several years and by the recommendation of not less than five members. . . ." The Institution goes on to say that "Associate Membership amounts to a professional qualification; full Membership is a distinction; and election to the Council (i.e., election as a fellow) is a high distinction." These institutions help to prepare the examinations for the National Certificates in their fields and "recognize" technical colleges as eligible for preparing candidates for the institution's own examinations.

I gather that the status of engineering in England is not quite all that it might be. The public image is still largely that of a man in dungarees with an oil can in his hand. Since there is no form of licensing, anyone can call himself an engineer—that is, Smith and Jones, regardless of any training they might or might not have had, can hang out a shingle, print up stationary, and go into business as "Smith and Jones, Engineers and Contractors." Engineering is slightly "non-U," and only 5% of the non-university students in science and engineering were pursuing their programs on a full-time basis in 1956.

If for no other reason, the Conference was extremely valuable in getting together for what I believe is the first time a number of representatives of the different types of engineering and scientific education in England in order that they might discuss their mutual problems, isolate and define the major ones, and set up machinery for seeking answers to them. When Mr. Peterson has completed his study, we hope to be able to print at least a review of it in the JOURNAL.

ENGINEERING COMBINED AT CASE

The creation of a new Engineering Division at Case Institute of Technology was announced in April by Dr. T. Keith Glennan, President, on the 80th anniversary of the opening of the first classes at Case.

Effective July 1, the new Engineering Division will replace the present departments of Civil, Electrical, and Mechanical Engineering, and Chemical Engineering (now a part of a combined department of Chemistry and Chemical Engineering).

The new Engineering Division will be headed by Dr. Ray E. Bolz, at present Head of the Department of Mechanical Engineering. Dr. Harry R. Nara, Head of the present Civil Engineering Department will be Associate Head of the Engineering Division.

For administrative purposes the new division will be considered as two groups, divided into an Engineering Design and Systems group and an Engineering Science group. Dr. Bolz will be responsible for the work in engineering sciences and Dr. Nara for the work in engineering design and systems.

International Opportunities and Obligations

GEORGE BROWNE

Chairman, Committee on International Relations, and Editor, Industria, McGraw-Hill Publishing Co.

My text is taken from a statement by Walker Cisler made as he stepped down from the Presidency of the Mechanicals. Mr. Cisler had this to say:

> There are serious imbalances in the present world situation as to population, natural resources, energy and technology. Millions exist close to the edge of subsistence. Human values are in jeopardy and countless individuals with great potential find little opportunity for self-development and social usefulness. Historically, in the more fortunate countries, tremendous progress has been made by the application of science and engineering to environmental opportunities. Much the greater part of our work remains to be done for the world at large and the need is most urgent. Here is a mission for the engineer. . . .

It is with this mission that we are concerned today and tomorrow. Whether we like it or not, we are in competition with Soviet technology in every part of the world. We are colliding with the Russians in outer space; we see them building the Aswan dam and roads in Afghanistan. In every underdeveloped country their interests match ours. And what a host of new underdeveloped nations with their myriad problems have burst upon the scene—Africa in a ferment of freedom and repression, peace and civil war, with Ghana going one way and Nigeria another; the Far East in continual turmoil with Big Brother breathing fire out of Peiping; our friends of long standing and equally long patience in Latin America getting more and more restive. And along with these passions, the pride of national emergence and the hope of economic development.

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The mission of the engineer is also concerned with the migration of U. S. industry and technology abroad. Right now the United States has an investment overseas amounting to about $32 billion. This investment will continue to grow and expand as companies seek new markets, new sources of research and development and an escape from rising production costs here at home. Under the best circumstances these ventures are in partnership with local capital and organizations. When executive and financial experts finish their negotiations, the engineers take over and on their efforts the success of the project hangs. Opportunities for employment abroad will increase. Engineers will find this work glamourous, difficult and profitable, but the profession has the responsibility of making sure that our people are adequately prepared. They must supplement technical experience with an understanding of other cultures and traditions and certainly with a speaking knowledge of another language. The international scene is one area where we can afford only to utilize our most effective men and women.

The engineer has a significant role to play in the foreign policy of the United States and in the programs of such international bodies as UNESCO and the Organization of American States. UNESCO and a number of private foundations are appropriating large sums of money for technological investigations in various parts of the world. The United States has its own technical aid programs. A new administration has taken office with the announced intent of emphasizing our efforts in the underdeveloped lands. Inevitably it will have to turn to the engineers for help and assistance. For better or for worse they will be the public face of the United States in these countries.

Will they be "ugly Americans" or "ambassadors with slide rules?"

It occurs to me that few people typify the engineer in this modern environment as do the former officers of the Committee on International Relations. The Chairman, Gail Hathaway, as Engineering Consultant to the World Bank, is as familiar a figure on the Indus River and in Bangkok as he is in Washington and New York. Brig. Gen. Stuart E. Reimel, the Committee Secretary whom we have honored, has for many years been a positive force for good will through his work with Large Dams, World Power and UPADI. And I commend to your attention the work of Bob Lea, another Committee member, who is devoting his life to the supply of technical literature to impoverished institutions abroad through the People to People Program. I regard it as most fortunate for the profession that the officers of Engineers Joint Council continue to demonstrate their concern for our international relations and their support of the Committee.

For all practical purposes the Committee on International Relations is the servant of the engineering societies in the care and maintenance of their relations with engineering organizations and activities beyond the borders of the United States. The Committee is a channel of communications, a coordinator of projects, a spokesman before the world for U. S. engineering in its broadest sense. It does not seek to take over relations or channels already established by individual societies or to develop international policies for them. Projects which it sponsors are usually carried out in cooperation with the society to which they naturally belong. The Committee's job is to cooperate, lend a hand where it is needed, push matters along.

The forces at play in the world around us are of such magnitude as to require this united front. There are, of course, degrees of interest among the societies in foreign affairs. But just as the individual citizen must walk a wary path, peering nervously over his shoulder in the direction of Laos, the Congo, Cuba, wondering what they may do to him, to his job, to his future, so the engineer, the society, Engineers Joint Council must take cognizance of world affairs—their effect on the profession and the contribution which each can make.

Let us consider for a moment some of the areas in which the engineer can make his peculiar contribution. Obviously the government and the international organizations offer magnificent opportunities. The Kennedy administration will undoubtedly re-organize the technical aid programs. Consultants in housing, road building, sanitation, energy, the development of natural resources will be needed. These programs get results when they are staffed with the right kind of people. What a splendid chance for the senior engineer who is not quite ready to retire and would like a further fling before he closes the books!

It will be necessary to re-establish relations with the Office of the Scientific Advisor to the President and with the National Science Foundation. Our advice and participation in their programs is highly desirable from all points of view.

Relations with engineering societies in other countries are becoming steadily closer. U. S. societies are joined with those of Western Europe in EUSEC, under whose patronage a number of useful projects have been undertaken. The Pan American Federation of Engineering Societies is 10 years old, still exhibits a few growing pains but is approaching maturity. A regional engineering organization for the Far East remains in the embryonic stage awaiting the breath of life. EJC holds the secretariat for the U. S. Committee on Large Dams and for the U. S. National Committee of the World Power Conference. In most of these activities we have the faithful collaboration of the Engineering Institute of Canada in as fine an example of international cooperation as you will find in the world today. Clearly EJC is a focal point for all engineers interested in international operations, and I urge anyone who wishes to be associated with this work to get in touch with the EJC Secretary, Mr. Wheelock.

I will mention two projects which may intrigue your interest. Last September the first Pan American Congress on En-

gineering Education was held in Buenos Aires. It was one of the most important meetings to take place in the Western Hemisphere, and its impact will be felt for years to come. The need in Latin America to produce more engineers, diversify them (the lack of sanitary engineers is particularly acute) and to improve the quality of engineering is great. Curricula must be reformed, full time faculties developed, equipment and facilities created. At a first step a series of engineering manpower studies will be authorized using the plan of the EUSEC study as a model. The United States will be an active participant in these studies drawing on its vast reservoir of experience and achievement. In doing so it will contribute not only to the progress of the profession of engineering but also to the betterment of Inter-American relations.

Equally full of promise is a proposal put forward by Pete Wisely of the Civils for an exchange of engineers. He suggests a cooperative effort among the national societies under the aegis of Engineers Joint Council to form panels of engineering specialists to tour abroad, lecture on and discuss engineering topics of "timely interest and need." His proposal has provoked a favorable response from societies overseas, and we foresee a two-way exchange once financial support is secured. Those who go out from this country and those who come to visit us will be particularly fortunate, but their new experiences and acquisition of knowledge will bring benefits to the entire profession.

Concluding these remarks I would like to put forward an idea which, so far as I know, has not been considered by anyone. In 1964 New York City will have a World's Fair. There has been some discussion of setting up a Museum of Science and Industry in connection with the Fair. Would this not be an appropriate time for Engineers Joint Council to convene a World Congress of Engineering and invite societies from every nation of the world to attend. It would be a job of herculean proportions to organize, finance and run such a Congress, but in terms of the interest aroused, achievements proclaimed, ideas interchanged, friendships formed and influence exerted it could be a most significant occasion.

I am convinced that today we need more and better communications on a world basis. Our international interests and operations, no matter where they are taking place or on what scale, are being conducted in a world which is growing steadily smaller. The jet plane takes you to London or Paris in 6 hours, to Rio de Janeiro in 10. The missile has made every part of the globe vulnerable. There are no shelters. Everywhere we are exposed—exposed to peace or to war.

This shrinkage does not mean that we have gotten to know or to understand or even to like peoples in other parts of the world—or they us. Cuba lies just off Key West, but we are all strangers to each other. The art of communications has simply not kept pace with the speed of transportation. Semantic confusion surrounds the politician and the businessman.

Communication presupposes both the ability and the desire to communicate. Nowhere are these values more evident than in the arts and sciences. There is always an audience for the writer, the musician, the scientist and the engineer. To a large extent we speak the same language as our colleagues abroad. They and we meet with respect and on a basis of equality—one professional man to another. We have a channel of communications. If we neglect it or do not use it fully and effectively, we will have failed both as citizens and as engineers.

GRADUATE STUDY AT DAYTON

The University of Dayton will inaugurate a graduate program in engineering in September. Actual courses to be given in the program, which will lead to the degree Master of Engineering, will be announced later.

Engineering and Technological Training for Underdeveloped Nations

A Report of the Engineering Workshop at the Fourth National Conference on Exchange of Persons

A. C. INGERSOLL

Dean, School of Engineering,
University of Southern California

"How can the advanced nations most effectively assist the underdeveloped nations in meeting their growing needs for engineering and technological manpower?" This was the basic question under discussion at the Engineering and Technological Training workshop of the Fourth National Conference on Exchange of Persons sponsored by the Institute of International Education in San Francisco, November 30–December 3, 1960. Under the general conference theme, "Educational Exchange for the Mutual Development of Nations," some 17 separate workshops convened the afternoon of December 1 to treat various aspects of the sub-theme, "International Training for Manpower to Meet the Needs of Nations."

To treat the engineering question the IIE had assembled a panel of engineers and engineering educators including Ibrahim Attour, Department of Water Resources, Kingdom of Jordan (currently a graduate student at University of California, Berkeley); Stephen Blickenstaff, Director of IN STEP program, Carnegie Institute of Technology; M. Dorman of the Bechtel Corporation; D. E. Hudson, California Institute of Technology; J. L. Meriam, University of California, rapporteur; and A. C. Ingersoll, University of Southern California, chairman.

The International Exchange Picture

In 1959–60, according to IIE statistics, there were 48,486 foreign students enrolled in U. S. colleges, from 141 countries ranging from Afghanistan to Zanzibar. Of this total, 11,279 (23%) were in engineering, the most popular of all fields of study among foreign students in the United States for the past five years. This year 32% of all foreign engineering students were from the Far East, 22% from Latin America, and 22% from the Middle East, three rapidly industrializing areas that have continued throughout the years to send us the largest numbers of engineering students.

At this same time, according to government figures, there were 1,590,000 American citizens living abroad, about one-third of them civilians. Of this civilian group, research scholars on foundation and Fulbright grants, together with other categories of undergraduate students and teachers, account for more than 10,000. Only 1% of American students abroad are studying in engineering fields. It is clear from this simple comparison that the United States' balance of trade in the engineering education market is heavily on the "export" side.

In view of the predominating flavor of engineering in many of the problems of educational exchange, it is surprising to find engineering educators playing a very minor role in meetings such as the one reported here. Of the hundreds of delegates to the Fourth National Conference, only an infinitesimal fraction had any direct connection with either engineering or engineering education.

Modern Engineering Education or Technical Institute Training?

One of the principal controversies growing out of this and other sessions of the conference related to the level of education and technology that the exchange student from an underdeveloped

nation should be getting in the United States. In most U. S. engineering colleges the foreign student takes the same program as the American student, with most of these programs now being strongly oriented toward basic science, with heavy emphasis on physics, computers, electronics, automation and the like, and minimum emphasis on the practical questions of how to get the job done. Too frequently the engineering student from the underdeveloped country becomes so familiar with and dependent on these sophisticated instruments and approaches that he is completely frustrated when he returns to his homeland and finds them unavailable or unacceptable in meeting the more prosaic problems of building dams and sewers, water works and power stations. The frustration is all too frequently compounded when the returning student finds it difficult to get a job in his home country which needs him so badly, and he looks longingly again at the United States, where there are commonly plenty of jobs waiting for his talent, and at "smashing" salaries.

One body of opinion, then, sees the present exchange programs as a great waste of teaching talent and facilities in "over-educating" the foreign engineering student or, more properly, not educating him for his real needs. The problem is complicated as one realizes that there scarcely exists in the United States today (or would it be more realistic to say that one would *hope* there did not exist) an engineering school that teaches the engineering of 25 to 40 years ago—the things needed now by the underdeveloped nations in their first stages of progress. Where in the United States can one learn today much about the engineering of motors and generators or internal combustion engines, to say nothing of steam locomotives?

A part of the answer to this question presumably lies in the technical institute, which has entered into the educational exchange picture only recently and in a modest way. Here it should be possible for the foreign student to learn the practical things he will need to know in building the machinery and public works that will advance his country in the immediate future. How strongly the foreign students and foreign governments will take to this idea is subject to much question. It is observed even now that the foreign student, especially the one supported by his family resources, is most conscious of the status symbol of the top half-dozen engineering schools in the country and has little thought of dipping any farther than he can help into the more broadly-based structure of engineering education in the country, to say nothing of the technical institute programs.

A reinforcement of the view that educational exchange should be at the highest level was echoed by some of the top leaders from the underdeveloped countries. "We'll meet the needs of tomorrow somehow," they said, in effect; "Help us to educate a generation of engineers for the long-range future development of our country, when we shall take our place beside the leading nations of the world." It seems clear that the new nation needs both training for tomorrow and education for the future and it seems equally clear that the best place to accomplish the technical training is in schools or centers established in the country where the work is to be done, that the student may continuously be reminded by local example of the task that lies ahead.

One panelist observed that we in the United States are far from clear on the purpose and place of the technical institute in our overall scheme of technical education. Until we are straightened out on this and the American technical institute has a recognized place in the sun, it may be premature for us to try to tell the underdeveloped nations how to utilize this institution in training technical manpower.

Again, the distinction between "engineer" and "technician" may be quite different in various countries and may lead to lack of mutual understanding in setting up educational programs. The U. S. educator engaged in an overseas exchange position must be careful to focus attention on the specific technical aims involved and not try to reform the educational system of the foreign country concerned.

Cost of Educating Foreign Engineers in the United States

The high and increasing costs of education and living in the United States are making educational opportunities for the unsponsored foreign student more restrictive. Last year only 5.5% of the 48,486 foreign students in the United States were supported by some type of grant from the U. S. Government, while 28% were supported by private organizations and 38% were self- or family-supported. To accomplish the desired goals in international education—expansion of foreign student numbers in the United States to an average of something like 12.4%, the current concentration at M.I.T.—an expanded program of the U. S. Government grants will surely be necessary to support capable foreign students who wish to apply for study in the U. S. but who do not have adequate resources or sponsorship.

It is of interest to remark here that the 12.4% concentration of foreign students at M.I.T.—some 4 to 5 times the U. S. national average—is just about the same percentage one would find on any typical European campus. We have a lot of ground to cover before we can bring our average concentration of foreign students up to that in Europe.

The Role of U. S. Industry and Government Agencies

United States industry enters the foreign technical manpower-training picture in 2 ways, first in its normal overseas operations and second in planned cooperative programs between foreign governments and U. S. industry. Following several excellent examples already set, U. S. industry abroad should serve as an effective window for foreign observations of successful U. S. industrial organization and technical know-how. In this way, U. S. industry can demonstrate that engineers can and do work in a very practical way. Further, increasing opportunity is afforded for using local talent—either with or without formal engineering educational background— which is in itself an excellent form of technical education.

Cooperative programs between foreign governments and U. S. industries can serve to accelerate the development of specific areas of technological need. An excellent example is the Indian Steel Training and Educational Program (IN STEP), in which highly selected groups of Indian students are given a carefully planned dual experience in U. S. steel mill operation and in a supporting educational program in a U. S. engineering school.

A number of training programs have been established for foreign nationals within U. S. Government agencies. One of the most successful of these is that of the Bureau of Reclamation, in which the foreign engineer spends one year in a training program that is tailored to his individual needs. Quite commonly this year is preceded or followed by a year of graduate study in hydraulics or irrigation engineering at one of the American engineering colleges.

Autonomy of Foreign Engineering Schools

Self-development through technical education requires an educational system which has adequate freedom and support. Although it was not the assignment of this workshop to treat the non-academic and non-technical affairs of foreign engineering schools, it was observed that schools in some of the underdeveloped countries are severely hampered in their programs by lack of full-time staff, by political control (both by government and by their own students) and of course by inadequate financial support.

One panelist recommended that governmental officials and educational leaders from individual underdeveloped countries be invited to inspect the operation of technical education in the United States as a *joint team*. Such planned visits would accelerate the understanding which these governments must acquire of the support and freedom needed by their universities. Although private universities do not figure significantly in the educational scene of these nations it would be helpful for the joint team to observe the balance between private and public education in this country, to see how the public institution establishes a

standard for support while the private school establishes a standard for independence.

Need for Better Educational Information

More complete information about the United States technical schools should be made available through appropriate United States offices to foreign countries so that prospective students and their sponsors can make a more intelligent choice of the type of program and institution best suited to meet the objectives.

A general lack of coordination appears to exist between industry, education, and our government in the dissemination of information and in the conduct of programs concerning international education, within and without the United States. It was recommended that the possible need be studied for a U. S. Office of International Education which would coordinate the many problems currently handled through somewhat scattered efforts.

Organizations on an international basis can and should be established to exchange views on technical and engineering education developments. The example may be cited of the recent First Pan-American Congress on Engineering Education held in Buenos Aires in September, 1960, attended by some 200 delegates from 16 Pan American countries, and sponsored by UPADI, the Pan American Union of Engineering Societies. The new East-West Center at the University of Hawaii may be a suitable avenue for a meeting that would focus on the opportunities for cooperation between the United States and the countries of Southeast Asia and the Far East in engineering education. It would seem that the ASEE should assume a leadership role in such a meeting, for what organization is better suited to lending its name and experience in the solution of problems, national and international, in engineering education?

Where Best to Educate the Foreign Engineer?

Up to a decade ago the only recognized participation of American educators and foreign students in international education (aside from missionary efforts) was in this country, where the teacher was on home base and the student was a stranger. This has continued to be the central contribution of American education, especially at the graduate level. As suggested earlier, however, there is good argument for conducting the education as far as possible on the student's home ground for maximum carry over.

Although statistics on the point do not seem to be available, it is well agreed that a major problem of the foreign student in this country is his reluctance to return home upon the completion of his academic work and apply his knowledge and skill to the uplift of his nation. The limited economic opportunities awaiting him in his home country have already been mentioned.

The panel was agreed that efforts should be made to reduce the number of foreign students who wish to remain permanently in the United States. In part this reduction can be effected by a more severe limitation on the maximum length of the study interval (suggested by one panelist to be one year). A long stay in the United States may involve disadvantages to the student such as loss of professional contacts at home, excessive withdrawal from his own social setting, and loss of seniority in government posts. Foreign governments should offer adequate job opportunities as an attraction to return home and could do so through better organization of study programs in relation to needs. While it will be easier to maintain contact and control over the student who is sponsored by his government, the foreign student whose study in the United States is supported by personal or family resources should also be made to realize his place on the "home team." His government should make every effort to assure that he will not be discouraged for lack of opportunity at home and persuaded to stay on in the United States, taking up permanent abode.

Many more of the competent students should be encouraged to take their advanced degrees in their own countries in order that their schools will develop the reputations necessary to attract an increasing number of their own people for

advanced degree work. In some cases this has been worked out in cooperation between the foreign university and its American counterpart. The foreign student pursues a doctoral program here, completing everything but the thesis at the U. S. school. He then returns home, with his research problem identified, performs the research, with some guidance by correspondence, and writes up a thesis. In conformity with the procedure used in most foreign schools, the thesis is reviewed by external referees, and of course one of these is the original major professor in the U. S. school.

How Best to Help Strengthen Foreign Engineering Schools?

Two major schemes have been undertaken thus far by the various programs in engineering education undertaken by the International Cooperation Administration. American professors have been sent (usually in groups) to engineering schools requesting such assistance in the participating countries. These visits have been, in general, of from one to three years with an average of approximately two. The counterpart scheme has been to have foreign professors—or graduate students destined to be professors—spend time in American colleges, pursuing either an advanced degree for credit or some planned program of visitation, sometimes in cooperation with industry or government agency as suggested above.

Placing an American professor in a foreign university has a good overall public relations effect and gives him a never-to-be-forgotten experience with foreign students at home, but it is quite likely to be a most inefficient means of communicating with the teaching staff of the foreign school. They are generally so badly overloaded with teaching and administrative detail that they have almost no time or energy for the necessary contact with the American professor. Especially if the visitor is on the campus for an extended period the overloaded teacher can always rationalize a delay in getting down to business with the visiting specialist.

In this connection more short-term assignments (2 weeks to 6 months) of United States technical people for foreign visitations should be considered. Short visits possess certain advantages such as a larger number of participants, greater compulsion to plan and execute a specific project, less involvement in local politics and other distractions, and avoidance of difficulties of transplanting families. In particular, the short-term visit opens the assignment to a whole range of high-caliber men who could not under any circumstances consider being away from their graduate students and research for as much as a year or two.

Teacher-Training Centers in Underdeveloped Countries

Combining the desirable features of removing the foreign teacher from his home campus and the innumerable distractions there, and the low cost of sending one American overseas in place of 10 to 20 foreign teacher trainees to this country, the foreign teacher-training center was suggested by a member of the panel. One or more centers could be established in the underdeveloped country so that the trainees would be within easy travel distance of their home schools and families, but they would be free of the niggling administrative tasks that make for so much distraction.

Training professors would be sent to the center from the United States and other advanced nations. Again, these terms would be shorter than the conventional overseas assignments in engineering education, but the pace of contact with trainees would be very much accelerated. It is not envisioned that the training center would be a research institution as well, for the research strength should be built on the campus of the permanent school. On the other hand, the philosophy of research as it relates to the total educational program, plus suggestions and ideas for research projects, would be part of the regular fare at the center.

These, then, are the principal observations, recommendations, and ideas generated in the workshop on engineering and technological training. If the discussion and the reporting have leaned more heavily on the engineering side

than on the manufacturing or technological, it is readily explained as a consequence of the makeup of the panel.

The past decade has been one of experimentation in the field of foreign technical assistance. After these 10 years of experimentation, the United States—and more particularly the International Cooperation Administration—may logically be expected now to establish certain permanent long-range programs of technical assistance. A few of the experiments have succeeded unquestionably. Several have failed unquestionably, of course, but the great proportion of them are clouded in their apparent success or failure because of the difficulties of accurate and objective evaluation. If through this workshop it has been possible in any small way to shed light on the complex matter of evaluation, and to make this light available to the various governmental and educational agencies engaged in technical cooperation programs, the effort of gathering the participants and of writing up this report will have been more than justified.

Teaching Positions Available

ELECTRICAL ENGINEERING. PH.D. degree required. Teaching experience desirable but not necessary. Excellent opportunity for young man interested in teaching electronics, network theory, control systems and computers at undergraduate and graduate level. Appointment effective September 1961. Write to Chairman, Electrical Engineering Department, University of Houston, Houston 4, Texas.

MECHANICAL ENGINEERING teaching vacancy: Ph.D. desired, Master's degree required, heat transfer emphasis preferred. Salary and academic rank dependent upon qualifications and experience. Apply to: Dean, Norwich University, Northfield, Vermont.

ELECTRICAL ENGINEERING. Teaching positions are open in the areas of circuits, digital computers, measurements, communications, control systems and electronics at the undergraduate level. Rank and salary are dependent upon qualification. Apply to the Acting Chairman, Department of Electrical Engineering, Essex College, Windsor, Ontario, Canada.

MECHANICAL ENGINEERING POSITION—to teach undergraduates and direct graduate programs in the thermodynamics—heat transfer field. Write A. W. Anderson, Chairman, Mechanical Engineering Department, North Dakota State University, Fargo, North Dakota.

TEACHING POSITION—SOIL MECHANICS and foundations. The undergraduate course is given in French. Ability to initiate and develop a research program in that field for the graduate school. Civil engineering experience and advanced degree required. Apply in French: Head, Department of Civil Engineering, Laval University, Quebec, Canada.

POSITIONS AVAILABLE IN ELECTRICAL Engineering, Mathematics, and Physics. M.S. required, Ph.D. desired. Salary and rank commensurate with qualifications. Apply: Earle M. Morecock, Dean, College of Applied Science, Rochester Institute of Technology, 65 Plymouth Avenue South, Rochester 8, New York.

ASSISTANT OR ASSOCIATE PROFESSOR of Mechanical Engineering. Will be responsible for courses in the field of Applied and Theoretical Mechanics. Must be interested in research. Ph.D. preferred. Write to Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

RESEARCH AND GRADUATE Teaching professorship in Mechanical Engineering is open in thermal power and fluid dynamics. Excellent opportunity for man with Ph.D. degree. Apply Head, Mechanical Engineering Department, The Pennsylvania State University, University Park, Pennsylvania.

(*Continued on page 843*)

Engineering and Education

A Statement Prepared by a Committee of the School of Engineering MASSACHUSETTS INSTITUTE OF TECHNOLOGY

March, 1961

Recent trends in college enrollment in engineering and science curricula suggest that the public image of engineering has been overshadowed by the popular attitude toward physics and mathematics. In an attempt to correct confusion in the public mind between engineering and science, a committee was appointed in the School of Engineering at the Massachusetts Institute of Technology to prepare a statement about engineering and engineering education. That statement is reproduced below.

Engineering is a profession. Its members do creative work which results in things that people need or want. These things may be highways, submarines, interplanetary vehicles, antibiotics, or television. Science, on the other hand, is a search for knowledge. The science of mathematics extends abstract knowledge. The science of physics extends organized knowledge of the physical world. In each of these consideration can be limited to a carefully isolated aspect of reality.

The engineer must deal with reality in all its aspects. He must not only be competent to use the most classical and the most modern parts of science, but he must be able to devise and make a product which will be used by people. Moreover, he must assume professional responsibility insofar as the safety and well-being of people are affected by the thing he makes.

A sound program which majors in engineering or one of its branches—civil, mechanical, chemical, etc.—will be the most stimulating and rewarding undergraduate experience for the great majority of candidates for engineering. They will find in it not only the science of the modern physicist, but also the other kinds of science—for example, fluid mechanics, or electric-circuit theory—which the engineer uses and develops as incisive means for resolving the complex problems of the real world. Such a program grows out of an educational environment created by men in contact with the world of people and industry which serves the people. It will include attention to the furtherance of many parts of science which are of special interest to the engineer.

Engineering education is being urgently called upon to produce graduates well versed in rapidly advancing science who will lead industry and the public into the new world which engineering will make possible. Engineers will often discover in science through their own research and invention or through the findings of scientists those things which can be put to human use. In any engineering achievement, however, the thing produced is the objective, and all means available to the intellect of man will be employed to reach that objective. Science and its application remain a part, but only a part, of any great engineering advance. Supersonic aircraft could have been devised and made only by engineers with great resources in science. In order to make the first supersonic airplane, however, science had to be combined with the engineer's drive toward creation of a predetermined object. Young people who can respond to this kind of challenge are needed now, but they will be needed as never before in the years ahead.

C. S. Draper
J. H. Kennan
T. K. Sherwood
J. B. Wilbur

Individual Projects

An Experiment in Engineering Education

WALTER McKAY

Department of Aeronautics and Astronautics
Massachusetts Institute of Technology

An experiment in engineering education by the project method was carried out during the 1959 fall term in the Department of Aeronautics and Astronautics at M.I.T. in conjunction with the teaching of a fourth year professional subject in automatic control. The experiment involved student selection and execution of 2 individual projects for each of which an oral presentation was made, a report written, and criticism received.

The students responded enthusiastically and diligently to the challenge of individual work and most did a good job. It is felt that they benefited greatly from the practice in presentation, from the experience of mastering new subject matter on their own, and from the necessity of considering more complex situations on a broader basis than previously.

The class of 54 students was handled by the writer with the help of a teaching assistant. Each of these devoted an average of 4.5 hours to each student in connection with his individual project effort. Although expensive in teaching time compared with ordinary group lectures, the results achieved seem worth the cost. The scheme is well adapted to fourth-year professional subjects in which the student has already had some basic preparation.

Introduction

This deals with an experiment in engineering education which was conducted in the Department of Aeronautics and Astronautics at M.I.T. during the term beginning in September 1959. In view of the recent interest in such experiments, it seems appropriate to report on any such endeavor. Subject 16.302, Aeronautical Systems, was taught as a required fourth year subject to a class of 54 seniors by the writer, with the competent help of Mr. Theodore Blaschke, Teaching Assistant. Teaching was by the individual project method and it was the use of this technique which made it an experiment.

Background

The fields of automatic control, aerodynamics, structures, and propulsion are considered by the Department to be the corner posts of its professional educational structure. Automatic control was added to the curriculum in 1954 and a course entitled Principles of Automatic Control was introduced as a fourth-year first-term subject. This was supplemented during the first term by automatic control laboratory exercises. It was further supplemented during the second term by an automatic-control design project. Also, during the second term, an elective subject entitled Aeronautical Systems was offered for students who wished to pursue this area further. In 1957 another curriculum revision was made in the interest of including further required work in automatic control. The first "principles" subject was moved to the second term of the third year and the "systems" subject was made required and moved to the first term of the fourth year. The present senior class is the first to have come through this latter program, and with the adoption of the curriculum changes in prospect at this writing, this will be the only class to do so.

The inability of engineers to write and speak well has long been held to be an inadequacy in engineering education. Engineers are by no means unique among professional men in this regard,

but this does not invalidate the criticism. Competence in writing and speaking can be improved if instruction in these arts is given and if opportunity for practice, under criticism, is provided.

The tendency of undergraduate students toward passiveness in their attitude toward education is frequently decried. Students are accustomed to listening to a lecturer and working problems and quizzes based on the lecture material. Learning acquired by individual work normally becomes possible only when a design project, experimental project or thesis is undertaken. It seemed worthwhile to try to extend the idea of individual work, so successful in these instances in developing engineering capability, to a subject which ordinarily would be taught in group lectures.

Previous experience in project teaching was obtained a year ago when the same subject, then elective, was taught on this basis to a small group. Student response was excellent and the results obtained were thought good enough to warrant a further trial.

With the foregoing in mind, this year's class was offered at the outset the choice between conducting the subject on an individual project basis or on a conventional lecture basis. After hearing the proposed ground rules and a pitch for the proposed experiment, the class voted for individual projects by a good margin.

Conduct of the Subject

During the term each student prepared 2 individually selected and executed projects, one of which was to be broad and general and the other narrow and detailed. Both written and oral presentations were made on each project. The oral presentations were 20 minutes long and were made before an audience of 8 classmates and 2 instructors. Thus in a 50-minute class period, 2 presentations could be made with 5 minutes available for discussion following each talk. Six groups, each meeting once a week during the last 10 weeks of the term, were formed to make this arrangement possible. Ten lecture hours were used in this way, the remaining class time having been used for lectures by the instructors.

TABLE 1

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF AERONAUTICS
AND ASTRONAUTICS

16.302 *Topics* 1959
McKay

Guidance
Inertial Guidance
Radio Guidance
Doppler Radar

Infra Red Systems
Sonar
Early Warning Systems
Air Traffic Control

Collision Avoidance
Automatic Landing Systems
Human Dynamics
Self Adaptive Control

Optimalizing Control
Sampled Data Systems
Cruise Control
Digital Computer Solution of Control Problems

Analog to Digital Conversion
Digital to Analog Conversion
Digital Differential Analyzer
Analog Integration

Analog Computer Solution of Non-Linear Problems
Bombing Systems
Orbit Control System
Operations Research

Reliability
Procurement
Information Theory
Information Storage

Information Coding
Telemetering
Data Recording
Data Reduction

Power Boost Systems
Artificial Feel Systems
Hot Gas Servo
Servo with Saturation

Servo with Backlash
Relay Servo
Hydraulic Servos
Jet Reaction Controls

Inertial (flywheel) Controls
Cockpit Data Presentation
Signal Shaping
Gyro Vertical

Gyro Compass
Transistors
Maser

A single hour quiz on the instructors' lecture material was given on the last day as a stimulus to interest in these lectures, no homework having been assigned. Grades for the subject were based principally on the individual projects.

Each student chose his own project topics, restricted only by conditions of relevance and non-duplication. As an aid in the selection of first topics, the list shown as Table 1 was distributed to the class. The students were urged to choose subjects of interest, either from the list or elsewhere, with which they had no previous familiarity. To the extent that this was heeded, the class revealed its interests and most strongly felt deficiencies.

The titles of the projects actually selected are given in Table 2 along with a summary classification of these titles.

Excellence of oral and written presentations was stressed as an important aspect of the projects. For the oral part, the students were asked to pitch their talks to a supposedly strange audience of their technical peers having no previous knowledge of the subject at hand. They were asked to prepare and practice for these as though their professional futures depended thereon. For the written part they were told that their writing would be judged as being the best they could do. A maximum length of 5,000 words was proposed.

The class was fortunate in having Professor Robert Rathbone of the Humanities Department give a lecture on report writing. Professor Rathbone has had wide experience in this field and gave a most useful as well as engaging lecture on the techniques of writing reports. He distributed excellent notes which were generally used by the class. Professor Rathbone also made himself available to individual members of the class for consultation and several students went to him for help as they wrote their reports.

Both the writer and Mr. Blaschke attended all oral presentation sessions and each kept score on the speaker's perform-

TABLE 2

PROJECT TOPICS AND ORAL PRESENTATION SCHEDULES

CLASSIFICATION OF PROJECT TOPICS IN ORDER OF POPULARITY

	No. of Projects
Automatic Flight Control	12
Instrumentation—Measurement Devices	12
Special Control Systems	10
Guidance	10
Control System Analysis	10
Digital Computer	9
Electronics	7
Control System Components	6
Radio Navigation	5
Air Traffic Control	4
Human Factors	4
Telemetering	3
Reliability	3
Communications	3
Servo	3
Infrared	3
Operations Research	2
Data Presentation	2
Analog Computer	2

FIG. 1.

Massachusetts Institute of Technology
Department of Aeronautics and Astronautics

16.302 *Student Project* Fall, 1959

Oral Presentation Criticism

(for students' use)

Name of Speaker:
Subject:
Relation to audience:
Technique of presentation:
Grasp of subject:
Content:
Suggestions:

ance, using the upper part of the form shown as Exhibit C. Although this form is more detailed than needed for most talks, all of the headings were used at one time or another.

During the latter part of the course, at student instigation, the oral performances were also scored by each of the listening students, using the form shown as Figure 1 for keeping the record. The purpose here was to foster a critical listening attitude and a feeling of nonpassiveness with regard to the talks.

The written reports on the projects were submitted at the time of the oral presentation. These written reports were read by both instructors within the following few days. During this reading the reports were annotated with criticism and the lower part of the instructor's scoring sheet (Fig. 2) was filled out. As soon as possible thereafter, normally 3 or 4 days after the talk, the student met privately with both instructors for a half hour to discuss both the substance of the project and its execution. Other

FIG. 2.

16.302 Aeronautical Systems Fall 1959

Student Project Report

Name:

Broad

Project Title (Narrow)

Date Submitted:

ORAL PRESENTATION

Presentation:

Relation to audience
Appearance
Speech clarity
Sentence structure
Speed
Blackboard/charts
Timing
Logical order
Proper emphasis
Shows practice

Content:

Problem defined
Approach
Important omissions
Overall opinion by:

WRITTEN REPORT

Organization
Clarity
Style
Paragraphing
Sentences
Choice of Words
Grammar
Spelling
Editing
Appearance
Credits
Bibliography
Emphasis
Major omissions
Understanding of subject
Previous background
Apparent preparation
Overall opinion by:
Date of interview with:

students' criticisms of the oral talk were also transmitted to the speaker, with identity protection of the critics.

At the end of the term, the students were asked to indicate their opinions of the whole venture, and for this purpose so-called feed-back sheets, of which a sample is shown in Figure 3 were distributed and collected from about half of the class.

FIG. 3.

Massachusetts Institute of Technology
Department of Aeronautics and Astronautics

16.302 *Feedback Sheet* Fall, 1959

Please state your reasons for choosing your topics. Availability of materials? Previous familiarity with subject? Other reasons?

Please indicate the preparation time for both projects

	First Project	Second Project
Hunting subject and material and study of same:		
Organization, writing, editing:		
Oral presentation:		
Total:	_____	_____

Please make any suggestions which you feel would improve the course

Should the course be made elective instead of required?

Although not involved in the individual project idea, the material included in the instructors' lectures will be mentioned for completeness. There were 30 such lectures which dealt with 4 topics. The techniques of analog computation with application to the organization of a flight simulator was discussed in 12 lectures. The next 5 lectures treated the problem of vertical indication in aircraft with emphasis on the increased difficulties associated with higher flight speeds. The next 9 lectures, given by Mr. Blaschke, presented the subject of random signals in control systems with application to aircraft gust response. A set of notes on this topic was prepared and distributed. Finally, 4 lectures were given on the general aspects of the measurement of physical quantities. An hour quiz on this lecture material was given at the end.

Results

The general feeling is that the individual project experiment was successful. The students gained much in having to choose two topics, run down and study reference information, organize, write and edit reports, prepare and present talks, and face criticism. They took their tasks seriously and worked hard to do a good job, devoting typically 40 to 50 hours to the preparation of each project. The prospect of speaking to an audience of fellow classmates stimulated their preparation efforts. Their level of accomplishment was better than had been expected with regard both to subject matter and presentation.

Choice of project was governed by interest in and desire to learn more about the topic. This is clear in the students' responses to the first question on the feedback sheet (Exhibit E). A few less enterprising students based their selections on the availability of library reference material.

The choices of projects as summarized in the classification of Exhibit B indicate a wide range of interests, with automatic control systems, instrumentation and guidance most popular but with computation and communications subjects close behind.

The oral presentations must be thought of as having been practice for the speaker and as practice in critical listening for the student audience rather than as effective teaching of new subject matter. Even a skilled teacher would have been hard put to present in only 20 minutes

some of the subjects which were attempted. In a number of the talks, the speaker left his audience behind early in the talk and, failing to realize this, went blissfully on his way. During the second round of talks, when this happened, the speaker was interrupted, usually by the instructor, in attempts to prevent complete bafflement of the audience, thereby giving the speaker some fringe benefit practice in coping with questions.

The students had been urged to practice their talks out loud in advance in order to help with timing, and most did well in this respect. Some were thrown off by failing to include blackboard work in their practice. Those who came off best had pre-drawn their illustrations either on the blackboard or on charts so that their precious speaking time was not used up in writing. Trying to write and talk at the same time is not for a tyro.

The making and keeping of contact with the audience varied greatly, depending primarily on the speaker's personality. The class had all kinds, from smooth performers to those who faced the blackboard and droned into space, even as some professors.

The 20-minute period for the talks was too short to permit adequate treatment of the subjects. The 5-minute discussion period which followed was even less adequate. Even though this was clear early in the schedule, no reasonable solution was apparent. Thirty minutes for the talk and 20 minutes for discussion would have been about right for both speaker and audience.

There was an unanticipated but definite psychological effect which came from holding the talks in a conference room where the audience sat around a table, rather than in a regular classroom. Several volunteered that this "set them up," making them feel as though they had arrived at a more participating level than they were used to in the classroom. The fact that the speakers wore a coat and tie may also have helped in setting the tone of these meetings.

Almost all the class turned in written reports which conveyed the writers' thoughts reasonably well. This is not to say that there were no writing faults, for indeed there were many, the nature of which are so well known that they need not be detailed here. Despite these, however, the messages got through. Most of these students, if they apply themselves to the task, can write well enough for professional purposes to get by. Given further writing practice under criticism, some could write well. Only 2 men turned out to be very poor writers. This handicap was evident in their secondary schools but did not interfere with their admission to M.I.T.

As to the students' thoughts themselves, as contrasted to the expression of them, the picture is not clear. The better men in the class knew what they were doing by the time they sat down to write. For the others, the necessity of meeting a deadline forced them to reveal a lack of adequate grasp of the subject in spite of their earnest efforts. How to acquire this grasp on one's own takes some learning and practice, and it is not to be wondered that some efforts were undistinguished. As examples of forms which this took, one may name failure to understand the underlying basis of the topic, lack of feel for the big picture, and unfamiliarity with hardware. The latter two of these are the result of inexperience and the nature of their education and should not be charged against the ability of the students. On the credit side, due to the broadness of the topics and to the instructions given for treating them, there was little escape into mathematical analysis in evasion of the subject.

It will be appreciated that generally the writing of these reports was done at the last possible moment, leaving insufficient time and energy for rewriting and editing. Admonitions to include this finishing step were heeded by only a handful of the class, as might have been foreseen.

The instructors' lectures were gratifyingly well attended even though the students were answerable for the material covered only in one quiz which they knew would have no more than a secondary effect on their grades. This portion of the subject was quite separate from the individual project aspect. These

lectures were aimed at the study of certain specific automatic control problems and included coverage of means of implementation as well as analytical techniques. It is felt that engineering flavor in these lectures was more important than the content.

The Cost

An education experiment of this nature can be carried out only at the expense of a larger amount of instructor time than is needed for teaching in the ordinary way. Apart from the instructors' lectures, the time devoted to the task by each instructor on a per-student basis was as follows:

Discussions with student relative to choice of subject and sources of information	0.5
Listening to two oral presentations of 0.5 hour each	1.0
Reading two reports at 1.0 hour each	2.0
Meeting student to discuss two oral and written presentations at 0.5 hour each	1.0
Total individual time per student for each instructor	4.5 hours

This adds up to a lot of time. If this scheme is more widely used, the teaching of a single subject becomes more than a full time assignment. It is not realistic to think that the technique can be widely used in undergraduate education. Its best application would appear to be to fourth-year subjects. This would permit the student to acquire enough basic background in the earlier years to equip him for this more professional type of effort.

The results achieved warrant this increased cost, if quality of education comes first. Feedback from the students indicates their satisfaction at having taken part in this experiment.

As a consequence of the relatively large amount of individual time spent with students, the writer became acquainted with them as individuals to a degree never before attained by him in a classroom relationship. On the students' side, they perhaps never before spent this much individual time with a staff member at M.I.T. The writer can say that he found that the personal rewards accruing from this far outweigh the psychic drain of doing the job.

TESTING SYMPOSIUM

A three-day symposium, *Physics and Nondestructive Testing*, will be held at Argonne National Laboratory on October 3, 4 and 5, 1961. The purpose of the meeting will be to stress the fundamental physics on which the technology of nondestructive testing is based. New methods or the application of concepts new to nondestructive testing will be included. Methods for the nondestructive evaluation of materials will be stressed rather than applications.

TECHNICAL INSTITUTE EVALUATION STUDY

The National Science Foundation has announced a grant of $47,250 to ASEE for an evaluation study of technical institute education. The general objective of this project is a profession-wide effort to improve technical education in technical institutes by conducting a study of the present role of technical institute education and its relation to engineering education.

The project will be supervised by the ASEE Ad Hoc Committee on Evaluation of Technical Institute Education.

Report to ASEE on The International Technical Congress of Agricultural Machinery, Paris, March 2–7, 1961

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I am pleased to report that as the official representative of the American Society of Engineering Education at the International Technical Congress of Agricultural Machinery at Paris, which was held March 2 to 7, the writer presented a paper entitled "Advanced Training in Agricultural Engineering for World Agriculture." This is a paper under the joint authorship of the writer and Dr. Merle L. Esmay of the Agricultural Engineering Department, Michigan State University. The Congress was held in the UNESCO Building in Paris and under the direct jurisdiction of the Minister of Agriculture for France.

The general theme of the Congress was the role of agricultural machinery in raising the level of human conditions, and in particular the assistance to countries in the process of development, as inscribed in the "Freedom From Hunger" campaign founded by the FAO of the United Nations in 1960.

It was brought out that two out of three persons in the present world are undernourished and that the number of inhabitants in the world is increasing more rapidly than the food resources; thereby, offering cause for concern not only in the present, but even more so in the future. At the Congress it was pointed out that the real problem is to give people the means to assure their own subsistence by increasing agricultural production, by putting new land under cultivation, by improving the soil, by irrigation, by preservation of land already under cultivation, by crop protection and by increasing the farmer's productive efforts. All this will also create an increase in the purchasing power of these countries and provide a solid basis for future development.

The solution of these problems requires that agricultural implements must be made available which are well adapted to the land, climate and local crops.

Key representatives were present from all of the major countries of Europe and America and from the USSR, as well as from most of the newly emerging countries of Asia and Africa.

Forty-four papers were presented. Each was given in four languages: English, French, German and Russian. Extensive use was also made of colored, sound movies, which were, in the writer's opinion, particularly effective in getting the story over.

It was apparent that not only the United States, but most of the countries of Europe, as well as Russia, are becoming quite active in this program to assist the emerging countries.

It is also apparent that we need better coordination of activities between the different agencies who are working in this field. There appears to be considerable duplication of effort; however, at the present stage it has not been too serious. As the program of education develops, however, this could be a problem.

It was apparent that one of the most important problems in world agriculture is water management and control, as large areas are either too dry or too wet to produce effectively.

The papers also brought out the fact that there is need for engineering design of equipment specially adapted to the various countries and equipment which the countries can afford to purchase or use.

It was apparent that education is the most important factor in solving the problems which are encountered in these countries. The tremendous variation in the educational level of the people poses very serious problems; however, they are not insurmountable. It appeared also

that the Land-Grant college type of educational system, such as is used in United States, should be very effective in most of these countries. The idea of combining classical education with technical education is just what is needed.

Many examples of excellent work being done by individuals who were trained in United States and Europe, and then returned to their country, was pointed out. It appeared to be the consensus that we should continue to have a broad student training program which would bring outstanding young people from the emerging countries to the more developed countries for training and that these should then go back to their native land, and with such help as is necessary, establish educational programs in their own country. This is the only way in which the education process can be carried on on a large enough scale to accomplish the result which is desired.

The writer's paper emphasized the good results which have been obtained through a graduate training program. This program is effective because it trains outstanding young men for leadership.

It was also apparent that along with the high level, or professional engineering training there is needed a training program on the technician level, to work directly with the producers.

The writer also had the opportunity to visit with Dr. McCune, Director of the Educational Program for UNESCO. This program deals with the over-all professional educational program in all fields and at all levels in the various countries of the world. Dr. McCune emphasized the necessity for building up the general educational level of the peoples of the various countries as a basis for the more professional and technical type of education, which was emphasized at the International Congress.

The writer was invited to return to Paris in April as a member of a Board of UNESCO who are in the process of developing a new, over-all, educational program. It was necessary to decline this invitation, however, on account of previous commitments.

It was a real pleasure to represent ASEE at this meeting, and to have the opportunity to visit with the representatives from various countries, and to inspect a number of educational, research and teaching laboratories in the various countries of Europe on this trip.

MEASUREMENT SCIENCE CENTER

This Nation's first measurement science center opened in February at George Washington University. Registration was expected to reach 100.

About one third of the enrollees are graduate students from government and industry seeking advanced training and experience. The remainder are enrolled as undergraduates in engineering.

This unique program—the only one of its kind in the free world—was organized by the university's school of engineering in cooperation with the National Bureau of Standards and with the assistance of the Martin Company of Baltimore.

The center will offer eight courses in metrology. Metrology is the study, development and application of highly precise measurement, and has not been available until now as a comprehensive university program in this country.

In a situation known as the 'measurement pinch,' American industry and technology has found that the need for precision measurement has far outdistanced the instrumentation and technical skills now available. Extremes and ranges of temperature; electrical, electronic and microwave measurement; factors of mathematics, mechanics and statistics often go beyond the ability of the measuring techniques and equipment in existence today.

The National Bureau of Standards, the agency officially responsible for metrology, and the George Washington University have offered to meet this need through a curriculum in measurement science. Students enrolled in these university courses can work toward engineering certificates or the degrees of bachelor, master and doctor of science.

An Experiment in Teaching Engineering Research and Creativity to Gifted Undergraduates

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"Creative thinking is the process of destroying one gestalt in favor of a better one."
Max Wertheimer

Even a cursory examination of the milestones in the history of science reveals that many of the greatest and most far-reaching ideas have been conceived by men in their twenties and early thirties. If we dare to generalize from these examples, it seems that an important function of higher education should be to provide educational programs that will give outstanding students in science and engineering opportunities to develop their creative talents as early as possible.

The creative process is obviously not something that can be taught in the ordinary sense of the word "teaching." It is not something that even a creative person lectures about or teaches to a student, no matter how gifted he may be. It does, however, seem possible to remove certain obstacles which might hinder creativity, to encourage gifted students to try out some of their ideas, to give them guidance once they have conceived ideas of their own, and to provide them with an environment in which they are not afraid to contradict the authority figures of their text-book learning.

A preliminary experiment in "teaching" research and creative thinking along these lines was carried out during the summer of 1960 at the University of Colorado, under the sponsorship of the National Science Foundation. The results of this program are sufficiently encouraging to warrant describing it, to indicate its strong and weak points so that others interested in carrying out similar experiments can benefit from the experience gained.

Philosophy and Objectives

In planning an educational program with such broad and difficult-to-define objectives as this one, it was deemed necessary to develop some guiding philosophy. Undoubtedly this step is one in which the personal background of the director plays a prominent part; the guide-lines of the present program are described in this paper, not for the purpose of recommending them, but rather to give the reader an opportunity to view the program more objectively.

Among the many goals of the program that of having each student acquire as much experience of independent work as possible stood out. But even a bright and potentially creative student, if left alone with a new and incompletely defined problem without any help, may make no progress at all. If, on the other hand, the teacher helps too much, nothing but routine work is left to the student. In addition to finding a "golden mean" to the amount of help, it seemed desirable that help given should not be limited to a particular problem, but rather to all sorts of problems the student is likely to encounter in his future career. In other words, the student should be helped to develop, not just a special technique, but the ability to search out, define, and solve problems.

Scientific research, not being a routine process, is very sensitive to the psychological state of the investigator. The investigators in this program were undergraduates in engineering whose experience was very limited and whose previous training had only been along the

lines of formal course work where success is usually equivalent to obtaining the "right answer." Considering the background of the participants, an important task to begin with was to remove the fear of failure, the fear of making a mistake by following a new and untried method of approach. To accomplish this objective, all the participants as well as some graduate students were brought together at the beginning of the program for a few informal lectures in which examples of research from the history of science [1] as well as from studies presently in progress were discussed. Emphasis was placed on following the growth and changes of ideas, on methods of approach, and on the mistakes and unsuccessful attempts at solving a problem. This was a very helpful and important part of the program. As a by-product, it also provided an opportunity for the undergraduates to become acquainted with the graduate students and laid the foundation for future cooperation between them early in the program.

For students who desired academic credit (6 of 7 participants) the program carried 3 units as a newly created course, "Engineering Research," offered by the College of Engineering. The participants were told at the beginning of the program, however, that no attempt would be made to evaluate their performance on the basis of the results they obtain, but that their methods of approach and original ideas would be more important than anything else.

Selection of Participants and Problems

The initial, and probably the most important, step is the selection of participants. We know very little about special characteristics and personality traits of potentially creative students. Help and advice in the selection process was given by Drs. K. R. Hammond and H. Gruber of the Behavior Research Laboratory at the University of Colorado. But research in the psychology of creativity is still in its infancy.

[1] Most of the examples were taken from J. B. Conant's book, *On Understanding Science*, a Mentor Book published by the New American Library.

The program was restricted to upper division students in the College of Engineering with a cumulative average of B+ or better. The availability of the program, which was scheduled to run for 10 weeks and provided a stipend of $600 for each of the participants, was announced in the campus paper. More than a dozen students expressed interest. Each of them was asked to submit a biographical sketch, in the form of an essay, describing his academic history, background and qualifications, and to state in detail his personal reasons for wishing to participate in the program. A critical perusal of these letters narrowed the list to 10 students—3 aeronautical, 2 civil, 1 chemical, and 4 mechanical engineering majors. After a few days 3 of these students decided to drop out. The remaining 7 students stayed with the program until the end; all but one plan to continue this work on a part-time basis during the coming academic year and to go on to graduate work.

In addition to selecting participants, suitable problems must be found. Ideally, each participant should select his own problem according to his particular interest and personal preference. This, unfortunately, did not seem feasible because of the limited time, funds, and equipment available. On the other hand, it was important that there be some choice for all and that the door to creative ideas not be closed. As a compromise between complete freedom in the selection of a problem and assigning a problem, the following scheme was adopted.

On the first day of the program a prepared list of about 20 problems was handed out. The problems on this list were generally side-lines of major research programs carried on by graduate students under the supervision of the program director. At the bottom of the list the possibility of suggesting "a problem of your own" was mentioned, but remarks cautioning the student not to overreach himself were added. Two students proposed suitable problems of their own; the others selected problems from the list.

This initial selection of problems offered the possibility of a fruitful interchange of ideas between the graduate students and the participants in the undergraduate research program. It also lightened the load of the program director because he was already familiar with much of the literature, the equipment, and the size of the problem; it had the added advantage that most of the necessary equipment was available.

Formal Conduct of Program

Research, as well as creative thinking, is concerned with searching out and solving problems. In this process it happens often that the initial point of view undergoes changes. At first the conception of the problem is incomplete, and the outlook of the investigator changes as progress is made. Although this growth process is very personal and varies from individual to individual, there are several stages which seem common to all.

The first stage is coming to understand the problem, to see clearly what is involved. The second is to see how the various items are related, how unknown is linked to known, and vice versa. In this stage a plan of attack is formulated. In the third stage the plan is carried out and finally the results are checked and reviewed.

In order to maintain a certain amount of control and continuity in the evolution of each participant's project, a rudimentary formal structure was imposed on the program. The entire group of participants as well as interested graduate students met once or twice a week for about 2 hours. During the first meeting the program was explained and, as mentioned previously, a list of 20 available problems was passed out. After the problems available for projects were handed out, potential industrial applications of the knowledge to be gained from this work were informally discussed. This seemed to encourage some of the students to let their imagination come into play and in one case resulted in a promising idea for improving the heat transfer characteristics of condensers and nuclear reactors.

The students spent the first week in the library, searching the literature, and gaining some background in those areas in which they wanted to work. The program director was available each morning for individual discussions, consultation, and guidance if necessary. Within this period each of the participants selected a project and at the second regular meeting each student gave a 15-minute discussion of his problem. The next 3 weeks were devoted to designing or modifying existing test rigs, selecting instrumentation, and formulating a method of attack. During this period a series of formal lectures was presented.[2] These lectures followed loosely certain topics selected from E. Bright Wilson's book, *An Introduction to Scientific Research*, (McGraw Hill Book Company, 1952). Particular emphasis was placed on statistics, design of experiments, and data reduction. The Kline and McClintock method of evaluating the accuracy of experimental data [3] was presented, and special lectures on the operation of certain instruments, such as a hot wire, a computer, a strain gage amplifier, etc., were also scheduled.

Whenever one of the participants progressed to the point where he wanted to begin his experimental work and start building or modifying equipment which required the expenditure of money, he presented his proposed plan of attack and a cost estimate in detail to the entire group. Although the students usually discussed their plans with the program director prior to presenting them formally, the questions asked by the group in the discussion period following the presentation of a proposed program proved particularly helpful and stimulating. After a given project was considered sound, the equipment was built by a machinist with the help and supervision of the student participant, who was responsible for the engineering construction. All but one of the participants had

[2] The author would like to thank Prof. J. Wagner and Dr. E. Condon for delivering some of the lectures.

[3] "Describing Uncertainties in Single-Sample Experiments," *Mechanical Engineering*, Vol. 75 (1953), pp. 3–8.

their experimental programs under way by the end of the sixth week of the program. The only student unable to finish his work suffered from an inability to properly evaluate his own capabilities. He thought very highly of himself, talked about very advanced and erudite subjects, but did not have a firm grasp of basic principles. After he became aware of his weakness, he settled down to work on a problem within his capabilities, continued to work voluntarily on it after the end of the formal program, and now plans to finish his project during the coming school year.

As the work progressed, the participants presented progress reports, and those who wanted academic credit were required to hand in a formal report. The observation, unfortunately all too common in engineering colleges, was made that even the most gifted students had extreme difficulties in presenting their work in writing without spelling errors and awkward sentence construction.

Examples of Work Done

A detailed description of the work done by each of the individual participants would be too lengthy; therefore, only a brief outline of the projects, as well as some of the highlights of the contributions made in the course of the program, will be presented.

Student A studied mass transfer from a rotating disk with free and forced induction. The undergraduate student working on this problem at first helped one of the graduate students to gather and reduce data. But he developed independently a new and better method of applying naphthalene on a test disk by repeated skin casting, checked results obtained by his method of casting with the old method, and then proceeded to study details of the flow pattern by using softer materials which leave erosion marks in regions where vortex rings are attached to the surface.

Student B investigated the decay of a turbulent swirl in a tube. He defined the parameters which are important variables and suggested some applications of industrial potential. He built a transparent test section, instrumented it to measure pressure drop, and developed a dye-injection technique suitable for flow visualization and photographic measurements. The project was B's own idea.

Student C intended to study the mechanics of flow through a rotating pipe, a system on which a graduate student was investigating the heat transfer Progress on this project was slower than anticipated and work is incomplete.

Student D developed a simple method for determining the torque coefficient of rotating disks, cones, and spheres. At first he designed a strain gage system with slip rings. Then he discovered a paper describing a method for determining friction coefficients of bearings and adopted the experimental technique to his needs. It required the determination of the angular position and velocity of a given point on the body as a function of time as the system is slowing due to friction. The first test rig he built used motion pictures and a timer. D plans to improve it and use the problem for a graduate thesis. The problem was D's own idea.

Student E worked on a study designed to investigate the separation effects due to nose spikes on various supersonic nose cone configurations. He set up the equations for reducing data on a Bendix G15-D digital computer.

Student F developed a technique for applying the "China Clay" method to indicate boundary layer transition in a rotating system and used the technique to investigate the influence of source flow on the transition point on a partially enclosed rotating disk. He also designed and developed equipment to do the same on a rotating cone.

Student G devised flow visualization methods using a smoke generator and high-speed photography. Previous attempts by a professional photographer on the same problem had only been partially successful.

Criticisms and Shortcomings

The only major criticism of the program was that the students were not

informed of their acceptance until a week before the program started, and that they were not given more time to think about their project and read up on their problem in the literature before starting their work. The first-mentioned shortcoming can easily be remedied. The inadequate length of preparation time, on the other hand, seems more difficult to overcome, since most students can not really devote their attention to the program until the pressure of their course work during the academic year ceases. A limited amount of preparation could, however, be done in the preceding semester if the summer program is a regularly scheduled offering.

Evaluation and Cost

It is difficult for the person who conceived and directed it to make an objective evaluation of a program such as this. There is not doubt, however, that the opportunity it offered the students to devote themselves for a fairly long period of time without the pressure of formal course work to studying a real problem on their own, to delving into the original literature in some depth, to organizing their own plan of attack, and to carrying it out, produced a spirit of enthusiasm which no laboratory course in which specific tasks are assigned periodically to a group of students can match. It also introduced the participants to problems of the real world, such as making cost estimates, laying out a time schedule, checking their own drawings and specifications with extreme care, and evaluating their own strong and weak points as research workers. For those students who were not sure whether or not they wanted to go on to graduate work, the program helped to clarify their future plans. The interchange of ideas between graduate and undergraduate students stimulated curiosity, and many a night one could see an undergraduate return to his desk with books from the library or come back to the laboratory to try out a new idea to overcome a problem that had arisen during the day.

To supplement the opinions of an undoubtedly subjective observer, some typical remarks of the students are quoted below.[4]

I would say that the undergraduate research program is a valuable educational experience since it provides an opportunity for independent study and a means for drawing together into an integrated picture seemingly unrelated material from several academic subjects.

Many things that have been learned now take on meaning.

I feel I have learned as much in one summer as I have learned in many years of previous schooling. This job enabled me to fit the many pieces of the academic jigsaw puzzle together. I see reasons for taking the courses I have already completed, and I am much more eager to take the rest and learn more. This was the first job I have ever had in which I actually used my college training to its full extent. The program provided me with a sense of accomplishment, and it gave me the incentive to learn much more.

It enables a student to see the need for graduate work and acquaints him with it in advance so that future plans can be made. It lets the student use his limited knowledge in applications that show results. It stimulates interest in a "field of scientific endeavor." At first I thought a lack of guidance existed in the beginning of the program, but now I think it is important to let the student find himself.

From a practical point of view one must also consider the cost of such a program. The figures quoted below are of course only approximations, but they should be indicative of the costs of similar programs.

Each student was allotted about $150 for the purpose of buying specialized equipment, material for building test rigs, and for expendable supplies such as film, flash bulbs, chemicals, glassware, and other small items required in his work. The cost of machining and assembling test rigs was approximately $150 per student on the average. This expense was borne by each student's department. All major pieces of ex-

[4] These quotes are from a questionnaire devised by Dr. H. Gruber for the purpose of studying gifted and creative students. The specific question from which these quotations were taken was "What do you think were the best features of the undergraduate research participation program?"

perimental and measuring equipment, such as a hot wire, a camera, pressure and temperature recorders, a stroboscope and a strobotac, and access to a small digital computer, were provided by current research projects and by the College of Engineering.

The supervision of the program required about half time of the project director. During the initial phases, when equipment was being conceived and designed, the load was heavier. On the basis of about $1000/month, the cost of supervision would thus be about $1,250 for a 10-week period.

An unpredictable, but probably unavoidable, expense is breakage of major equipment. In this program a special electronic pressure recorder was overloaded by one of the students. It required repairs of approximately $600. This was of course not budgeted for in the original proposal, and had to be paid by the College of Engineering.

As a guide for future programs of this type, say for a group of 10 students, a reasonable minimum overall cost estimate based on the experience of this program would be about $12,000, excluding overhead and major breakage.

Summary and Future Plans

The following conclusions have been drawn from the experimental program of undergraduate research participation described in this paper:

1) Gifted undergraduates are capable of conducting research with a minimum of supervision and in some cases can make original contributions.

2) An undergraduate research program is an excellent preparation for graduate work and seems to provide fairly clear evidence about the potentials of the participants as research scientists.

3) The minimum cost of a 10-week summer program is $1,200 per student for a group of 10 participants.

4) A successful undergraduate research program requires careful planning, and its chances of success are enhanced if it can be coordinated with current graduate research.

5) Despite the limited experience and background of the participants, each of them seemed to acquire a "feel" for the tactics and strategy of science and engineering in the course of the program.

The College of Engineering at the University of Colorado is instituting a Superior Student Program for potentially gifted students next year. The Undergraduate Research Participation Program appears to be a valuable educational experience for superior students and it is hoped that such a program can be scheduled regularly in the future.[5]

[5] The author gratefully acknowledges the assistance rendered by Prof. H. Johnson in supervising the program for several days during his absence, the help and advice of Dr. L. Garby and Mr. E. Meyers in building equipment, and Dr. J. Allen's critical review of the manuscript. He also wishes to thank the participants for having made this program a rewarding experience.

ENGINEERING SCIENCE AT RPI

Establishment of an engineering science curriculum at Rensselaer Polytechnic Institute effective in September has been announced by Dr. Clayton O. Dohrenwend, vice-president and provost.

The first three years of the program provide courses in basic science, mathematics and engineering science that place greater emphasis on the mathematical and analytical approach than is true of most other engineering curricula. For his senior year program, however, the student is encouraged to elect a sequence of courses either of a physics-oriented nature or chemistry-oriented nature to suit his personal interests and objectives.

Cooperative vs. Competitive Learning

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The increasing complexity and magnitude of engineering projects has led, in industry, to the widespread use of the group or team approach to the solution of problems. Within such groups or teams, engineers must learn to work in a cooperative, or at least non-competitive manner to facilitate the achievement of a given group objective or goal. Many studies have been conducted in industrial settings to determine what effect cooperative effort has on group achievement, and also to determine how cooperation within the group can be established and maintained.

An analogy can be drawn between the engineering group or team in industry and the (ad hoc) group of students in an engineering classroom if we define the goal of the student group to be "learning." It then becomes interesting to examine what effects cooperative and competitive attitudes and environments may have on individual achievement in this student group.

Before doing so, let us examine some apparently unrelated concepts and then proceed to illustrate how these concepts may operate in the classroom setting.

Firstly, we might consider R. B. Cattell's [1] synergy concept. Cattell divides the *total* goal seeking energy (which he calls "synergy") invested in a group by its members into two parts: 1) the part that goes into internal friction and group building and maintenance roles, 2) the part used to carry out the explicit purpose of the group.

The energy expended in individual roles is definitely not available for task achievement.

The energy used in group building roles, while not directly available for task achievement, probably does contribute to the task achievement if it promotes amicable interchange of ideas and opinions among the participants and facilitates the acceptance of a common group solution.

Secondly, there is a concept which can be called the Rule of Precedence.[2] Briefly this may be stated as follows: behavior associated with personal or interpersonal anxiety takes precedence over behavior directed towards task achievement. In our model (Fig. 1) we might say that the internal work requirements must be satisfied before considering the remaining energy available for useful work.

The third concept is concerned with motivation. What makes people do things? No one has yet developed a generally acceptable answer to this question. However, underlying many of the currently proposed answers seems to be the somewhat ambiguous idea of the *life urge* or will to live (what Henri Bergson called, "elan vital"). In the past, where man lived in a world of real or imagined

[1] R. B. Cattell, "Concepts and Methods in the measurement of group syntality," *Psychol. Rev.*, Vol. 55 (1948), pp. 48–63.

[2] N. G. Flanders, "Personal-social Anxiety as a Factor in Experimental Learning Situations," *J. Educ. Res.*, Vol. 45 (1951); pp. 100–110. E. S. Jones, "College Graduates and Their Later Success; a Study of Data Concerning Male Students of the University of Buffalo Related to Their Careers Twenty Years after Graduation," *University of Buffalo Stud.*, Vol. 22 (1912), pp. 117–208.

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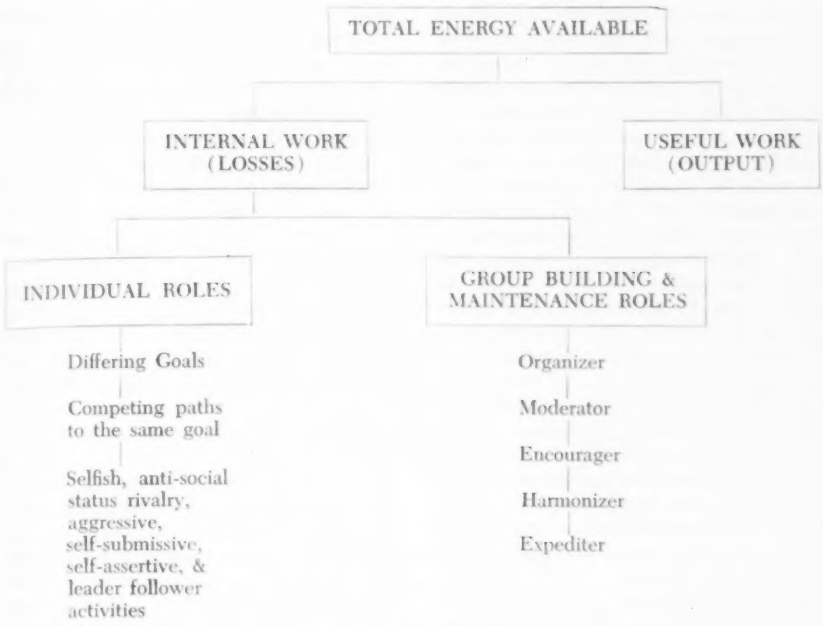

FIG. 1. Synergy concept.

scarcity, this life urge resulted in a competition for what was envisioned as an adequate share of the limited resources. People competed for what were mutually exclusive goals—and acted more or less in accordance with the "law" of the survival of the fittest.

We are told that competition is a "natural" or inherent characteristic of human behavior. However, a careful scrutiny of history reveals many examples of cultures which did not exhibit the rather widespread competitive spirit characteristic of modern western society. The serfs of the European middle ages and of the Inca civilization were notably lacking in this competitive "characteristic." W. F. Ashly Montagu, in his book *On Being Human*, suggests that there is just as much evidence for supporting man's cooperative characteristics as there is for his competing characteristics. Furthermore, perhaps for the first time in the history of man, there is the possibility that we can live in a world of abundance rather than scarcity, and if some of the human energy currently expended in competitive conflict to determine who gets what share of a small pie, is instead expended in helping to create a bigger pie, some of our Malthusian fears might disappear.

A fourth concept, and perhaps the most important one, is that concerning significant or meaningful learning. This concept stipulates that learning is not the accumulation of bits of knowledge. Learning does not become significant until the student remakes or synthesizes the bits of knowledge into a meaningful whole, related to his previous experience and resulting in a change in attitudes, beliefs or patterns of behavior. Such a definition of learning makes the learning process a personal matter, very largely dependent for its success on the willingness and needs of the individual student.

Let us examine, now, these various concepts in relation to the classroom setting. We might return to our first model (Fig. 1) and decide that the ideal situation is one where all of the available energy is utilized in providing each member of the group with the maximum op-

portunity for meaningful learning. However, some of the energy which could be directed towards this goal is lost in internal work or friction, and part of this friction within the group arises because the goal is not viewed as being mutually attainable by all, but rather as an exclusive prize to be won by successful competition against others. If this seems an exaggeration, ask any student how he feels. Students compete to enter a college of their choice, and they compete to stay in. And to the extent that students view their schooling as job preparation, they compete to acquire tangible signs (good grades, honors, etc.) of proficiency in this attainment. This competitive attitude is continuously reinforced by the daily encounter with the effort-reward pattern common in many classes. If you study hard, you do well on the exam and you get a good grade.

Except in rare cases, the student seldom stops to consider such things as a common class objective in learning. This competition for the few "A" grades meted out to a class is often consciously, and almost always unconsciously, fostered by the instructors. Sometimes the instructor unconsciously measures the students against himself (the instructor), and this can be extremely frustrating to the student who may feel that he could never reach the instructor's level of attainment. Most often the teacher measures the students against each other. Now, in both cases this is imposed learning, goaded from the outside and not necessarily related to the student's own need or readiness to make a meaningful experience from the educational process to which he is being exposed. Stated another way, significant learning is essentially self-learning and self-discipline. An externally imposed discipline, whether it comes from parental pressure, the threat of bad grades, or competitive striving, may increase the student's storehouse of elemental bits of knowledge, or may raise the grade-point average of a university, but probably does little to increase meaningful learning.

It is interesting to note here that the word *discipline* comes from the Latin *descere*, to learn, and the ancient concept of learning was to a large degree what we would call *self*-discipline. Notice that we have to add the qualifying *self* because the current connotation of discipline is that which is related to external rather than internal sources.

So far we have examined only *concepts* and unsupported conclusions. Whether they are accepted as valid or not probably depended largely on what previous notions or experience on the subject each of us has had. However, this field has not escaped its share of scientific investigation. The results of these experiments are by no means conclusive, and do not be surprised if there are contradictions in the various experiments, or if our personal conclusions about the experimental evidence differs.

Very few of the experiments attempt to measure meaningful learning, that is learning which results in changes in attitudes, beliefs or patterns of behavior. One reason that this is not done is because of the difficulty in measuring such changes. Most of the experimenters, therefore, report on knowledge of subject matter, rather than on meaningful learning. This distinction is important to note because there are situations where one student may have assimilated into his personal experience more than a second student and still remain less knowledgeable about the subject than the second student. Such a situation probably arose in Asch's non-directive teaching experiment.[3] A group of students in a non-directive teaching class were informed at the beginning of the semester that there would be no final examination. When they were tested at the end of the semester they did not do as well as a standard lecture class that was used as a control group. Probably they were not as well prepared for the *test* as the control group. Raven [4] found that students were better prepared if he told them at the beginning of the semester that there would be a final exam. What may be happening here is that if a student dis-

[3] M. J. Asch, "Non-directive Teaching in Psychology: An Experimental Study," *Psychol. Monogr.*, Vol. 65 (1951), No. 4.

[4] B. Raven, "Leadership and Social Influence," *Adult Leadership*, March, 1959.

covers that in one isolated class he does not have to prepare for a final exam, then he translates his energy to the other classes where the competitive requirements remain. (Leslie Greenhill at Purdue University has called this "The Law of Compensatory Effort") This suggests that if a non-competitive system is inaugurated, it must be on a school-wide basis.

A more carefully controlled experiment than Asch's was recently conducted by Haigh and Schmidt,[5] who found that there was no significant difference in knowledge of subject matter at the end of the term between a group which was not required to learn by the examination-grade system and the normal control group.

Deutsch [6] made an interesting study of the effects of cooperation and competition upon the group process. He divided his students into five-man groups, some of which were encouraged to work cooperatively by being told that they would all receive the same grades based on the total group product, while other groups were encouraged to work competitively by being told that each member of the group would receive a grade commensurate with his individual contribution to the group product. The groups were given puzzle-solving and discussion-type problems. The cooperating group showed greater coordination of efforts, greater diversity in the amount of contributions per member, more subdivision of activity, greater achievement pressure, more attentiveness to fellow members, greater comprehension of inter-persons communication, orderliness, quality of product, friendliness and favorable evaluation of the group product than the group which did not work cooperatively. In this experiment it appears that the competition for mutually exclusive goals restricted communication of ideas, coordination of efforts, friendliness and group harmony. Deutsch also indicated that competition could also produce greater personal insecurity with expectations of hostility from others. He strongly criticizes competitive grading systems and raises the question whether such competitive grading systems produce the kinds of inter-relationships among students, the task directedness, and the personal security that are in keeping with sound educational objectives. However, here again there was no significant difference between the groups in the amount of individual learning.

Henry Clay Smith's experiment on teamwork in college classes is also worth careful consideration.[7] Smith placed students of matched initial achievement in a team-work class and in a traditionally-taught control class. A rather unique grading system was used on the team class in an attempt to encourage group cohesion. This class was informed that in addition to the usual individual grading system, each member of the team which did the best work would get a bonus of five points on his grade, and that each team would also have ten grade points to distribute amongst the members as they saw fit. However the students in the team class were very unhappy with the group incentive grading system and Smith suggests that the reason for this was that the students felt unjustly individually penalized when their group did not do well in the inter-group competition. But let us examine what was happening, because this experiment illustrates one pitfall in equating group work (or team work) with cooperation. While Smith called one class a team-work group and tried to encourage group cohesion, he retained the traditional individual competitive grading system for each member in the group and in fact added an additional group competitive goal by the five-point bonus incentive. No wonder the students were unhappy. They were also probably confused. On the one hand they were being told that they were a cooperating team and on the

[5] G. V. Haigh, and W. Schmidt, "The Learning of Subject Matter in Teacher-centered and Group-centered Classes." *J. Educ. Psychol.*, Vol. 47 (1956), pp. 295–301.

[6] M. Deutsch, "An Experimental Study of the Effects of Cooperation and Competition Upon Group Process," *Hum. Relat.*, Vol. 2 (1949), pp. 199, 231.

[7] H. C. Smith, "Teamwork in College Class," *J. Educ. Psychol.*, Vol. 46 (1955), pp. 274–286.

other hand they probably sensed that they were being rewarded for successful intra- and inter-group competition. Here again the overall achievement gains of the team class was not significantly better than the lecture class.

Smith's experiment highlights the possible confusion between group work and cooperation. While group-centered classes may be one way of increasing student cooperation, it is not by itself a guarantee of such cooperation. Perhaps the emphasis does not even have to be on cooperation. A large amount of individual-centered effort should be retained and encouraged. Task-directed anxiety need not be removed. What should be removed is the anxiety and unmeaningful effort expended in *competitive* activities which contribute nothing to the task achievement—which do not add to the student's significant learning.

Competition can arise from many sources, some of them not immediately evident. For example, the size of a class may affect the competitive attitude of the students. Carter, Haythorn, Meirowitz and Lansetta [8] indicate that in order that each individual have sufficient opportunity for self-expression and display of his abilities the group size should not exceed four members. If the group is larger than four members, only the more forceful individuals are able to express their abilities or ideas, and there is constant competition for the opportunity of self-expression.

However, this may not be the whole story. Opportunity for self-expression may depend on factors as important as or even more important than group size. Group structure may be one of these factors. The point to note here is that the social climate of the class, upon which the extent of participation or isolation is dependent, is not entirely due to the summation of the member personalities. It can be established in part, a priori, by careful planning on the part of the faculty. This was amply demonstrated by Robbins [9] when she succeeded in establishing in different college classes "democratic," "laissez-faire," and "autocratic" atmospheres. And it should be just as possible for thoughtful faculty members to establish a non-threatening, non-competitive classroom atmosphere.

Of course, if an instructor should attempt to structure his class in such a fashion as to reduce the undesirable personal and inter-personal anxieties, he should be certain to inform the students of his reasons for so structuring the class. This is particularly true since the structure may be different from that to which the students are accustomed and it may be difficult at first for the students to accept a new orientation toward their class work. Students have developed such an elaborate system of anxiety defenses that they are initially suspicious of a situation where these defenses may not be useful.

The success in setting an appropriate classroom atmosphere depends ultimately on the individual teacher. Now the teacher's attitudes are the products of his own experiences and sometimes these have been of a competitive or authoritarian nature, and so he is likely to perpetuate the authoritarian relationship, which tends to threaten rather than encourage genuine pupil growth. Such a teacher will enter the classroom each day with a preconceived idea of what is "good" for the students to do or to know. This, of course, is a personal judgment on the part of the teacher, and may not be related to the student's needs. There is the danger that such a teacher will fail to distinguish between his own personal needs (as an individual) and the needs of the students in the learning situation. Perhaps Comenius had this in mind as long ago as 1630 when he said: "Let the main object of this, or didactic, be as follows: To seek and find a method of instruction by which teachers may teach less but learners may learn more."

There is no need for all our teachers to become like David Reisman's "other-directed man." Rather, the teacher should seek non-coercive and non-threat-

[8] L. Carter, W. Haythorn, B. Meirowitz, and J. Lansetta, "The Relation of Categorizations and Ratings in the Observation of Group Behavior," *Hum. Relat.*, Vol. 4 (1951), pp. 239–254.

[9] F. G. Robbins, "The Impact of Social Climate upon a College Class," *Sch. Rev.*, Vol. 60 (1952), pp. 275–284.

ening methods of instruction. Raven suggests that *informational influence* can result from the content of the communication from the leader to the member.

"The teacher strives for informational influence by presenting material in a factual and organized fashion. If the teacher is successful, the change in behavior or opinion which results will be independent of the teacher.

The student will not answer in a specific way to get a good grade and reject this knowledge when surveillance by the teacher is no longer possible. Nor will his altered behavior depend upon his accepting the legitimate right of the teacher to influence him, or his acceptance of the expertness of the teacher, or his admiration for the teacher.

This does not deny that an instructor must necessarily rely on his expertness at times—as a chemistry professor may prescribe a particular laboratory procedure before the students are able to comprehend fully the basis of the procedure. However, it does suggest that in education, the instructor must be aware of the importance of information power while avoiding other types of influence wherever possible, if he wishes his instruction to have lasting effect."

Suppose we do succeed in establishing a non-threatening class-room atmosphere, where the students work together and not against each other—what about grades? How do we detect poor students or weak areas? How do we encourage good students?

First if the school entrance testing procedure is a reliable one, we shouldn't have to do subsequent weeding. Accept the fact that students will not do equally well in all areas. Try to establish objective learning goals: Curriculum evaluation studies, (such as the one currently being conducted in the Department of Engineering, University of California, Los Angeles) should help accomplish this. When a student meets these objective standards he passes. Under such a system some students will go faster than others.

To paraphrase B. F. Skinner [10]: "Students may continue to be grouped in 'grades' or 'classes,' but it will be possible for each to proceed at his own level, advancing as rapidly as he can. The other kind of 'grade' will also change its meaning. In traditional practice, a "C" means that a student has a smattering of a whole course. But if [objective learning goals are established] a grade will be useful only in showing how far a student has gone. "C" might mean that he is halfway through a course. Given enough time, he will be able to get an "A"; and since "A" is no longer a motivating device, this is fair enough. The quick student will meanwhile have picked up "A's" in other subjects."

Secondly, in view of the great difference in grading techniques used by different teachers, it is questionable what the real significance of such grades are, other than as competitive stimuli. Some universities have tried eliminating grades. One university, however, made the mistake of merely not giving grades to the students, but did continue to keep them for confidential "office" uses. The students, instead of welcoming the absence of grades, worried more about what the secret records showed. They also missed the periodic feedback on how well or poorly they were doing. The solution, as suggested above, seems to be to deemphasize grading on a curve and use instead an objective measuring scale.

Reducing the competitive anxieties, which constitute so much of the individual roles shown in Figure 1, is no guarantee that released energies will be used directly for task accomplishment. There is considerable experimental evidence which indicates that much of this energy goes into socializing. However, this is in itself a significant point. The energy may not be going into learning more bits of engineering knowledge, but it is going into a type of learning activity that is perhaps just as important for the professional growth of an engineer, and that is, the engineer's ability to take his proper place as an active participant in community life.

[10] B. F. Skinner, "Teaching Machines," *Science*, Vol. 128, No. 3330 (1958), pp. 969–977.

How Much Graphics?

A Survey of Graduate Engineers In the State of Wisconsin

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During the past few years engineering drawing has held a controversial position in the engineering curriculum. There has been a general trend in the reduction of time alloted to the study of engineering drawing and descriptive geometry. Previous studies [1] have been criticized on the basis that the sampling was taken primarily from draftsmen or other personnel not directly connected with engineering. As a result, these studies have been of limited use when changes in the engineering curriculum affecting engineering drawing were under consideration.

Here, at the University of Wisconsin, the amount of time devoted to the study of engineering drawing and descriptive geometry has also been reduced. Recently, further reductions have been contemplated. The problem became acute when the electrical engineering curriculum was revised to drop drawing from the required list and put on an elective basis for those students who had no previous (high school or industrial) experience in engineering drawing. Descriptive geometry was omitted entirely. These changes demanded an evaluation of the present drawing courses.

Purpose

The process of evaluation is aided by knowing what a graduate engineer thinks of a course after he has had the opportunity to judge its value in light of his own industrial experience. The basis of this study then, is the collection and comparison of such opinions of graduate engineers with respect to engineering drawing.

The Questionnaire

To obtain the maximum number of opinions, a questionnaire was used.

A preliminary questionnaire was formulated and distributed to the boards of directors of the following engineering societies, Milwaukee chapters, for criticisms and comments: American Institute of Electrical Engineers, American Society of Civil Engineers, American Society of Heating and Air Conditioning Engineers, American Society of Mechanical Engineers, American Society of Metals, Institute of Radio Engineers, Milwaukee Chemical Engineers Club, Society of Automotive Engineers, Wisconsin Society of Professional Engineers.

This led to the final format of the questionnaire, and at the same time established the cooperation of these societies in making the questionnaire available to their membership.

At first, arrangements were made to present the questionnaire at the monthly meetings of the various societies, but this procedure proved to be unsatisfactory. Irregular attendance and the large number of meetings that would have to be attended made this procedure unwieldy.

The direct mailing method was chosen as the primary method of distributing the questionnaire. The societies were very helpful in making their mailing lists available and one, The Society of Automotive Engineers, paid the costs of mailing.

Table 1 shows the number of copies sent to the engineering society members by the methods indicated. The use of

[1] R. S. Paffenbarger, Chairman, "Industrial Relations Committee Report," *Journal of Engineering Drawing*, Vol. 21, No. 2 (May, 1957), pp. 12–17. O. W. Potter, "Is Drawing Important to the Practicing Engineer?," *Journal of Engineering Drawing*, Vol. 18, No. 3 (November, 1954), p. 29.

the mailing lists had the advantage of covering the entire State of Wisconsin and surrounding areas, but naturally concentrated in the industrial sections.

Total returns numbered 1,067 for a percentage of 30.6, but 62 of these had to be eliminated because the individuals did not have a degree. Therefore, the total number of usable returns was 1,005 or 29% of the questionnaires distributed.

Grouping of Data

The returns were grouped according to the branch of engineering represented by the degree. These groups were (1) mechanical, (2) electrical, (3) civil, (4) chemical, (5) metallurgical and (6) "other." The "other" group included industrial, agricultural and aeronautical engineers.

Each group was subsequently divided according to the year of graduation. For this purpose, three groups were established. Group A included all engineers who were graduated prior to 1943, Group B, those who were graduated during the years 1943–1953 inclusive, and Group C consisted of those engineers who were graduated from 1954 to 1959.

These particular year groups were chosen because a previous study[2] indicated that it took the average engineer one to five years, after graduation, to settle in a particular field of engineering; that it took an additional one to ten years for him to establish himself in this field and only after that did he become a leader or executive.

TABLE 1

Organization	Personal Contact	Mailing
American Institute of Electrical Engineers		1,000
American Society of Civil Engineers		560
American Society of Heating & Air Conditioning Engineers	70	
American Society of Mechanical Engineers	45	
American Society for Metals		150
Institute of Radio Engineers	30	
Milwaukee Chemical Engineers Club	30	
Society of Automotive Engineers		1,000
Wisconsin Society of Professional Engineers		600
Total	175	3,310
Total Copies Distributed		3,485

TABLE II

NUMBER AND PERCENTAGE OF RETURNS BY BRANCHES OF ENGINEERING AND YEAR GROUPS

	Group A	Group B	Group C	Total	%
Mech.	125	126	41	292	29.0
Elec.	120	159	68	347	34.5
Civil	72	88	59	219	21.8
Chem.	26	12	3	41	4.1
Met.	33	23	29	85	8.5
Other	8	9	4	21	2.1
Total	384	417	204	1,005	100.0
%	38.2	41.6	20.2	100.0	

Table II indicates that the distribution of returns from three major branches of engineering is fairly even. The largest group of returns is from electrical engineers. This is in keeping with the purpose of the study since electrical engineers have been very active in curriculum changes. The distribution of returns by year groups is even more applicable in that the majority are in Group B who are likely to be in a better position to evaluate their education.

The data were further sub-divided according to the advanced degrees held. Table III gives a breakdown of the degree distribution.

Note that the only significant difference in Table III occurs in Group C, in the relation between B.S. and M.A. degrees, and the other groups. It should also be noted that the percentage of advanced degrees held correlates closely with the Purdue study.

[2] G. A. Hawkins, E. C. Thoma, and W. K. Lebold, "A Study of the Purdue University Engineering Graduate," JOURNAL OF ENGINEERING EDUCATION, Vol. 49, No. 10, (June, 1959), pp. 930–947.

TABLE III

DISTRIBUTION OF DEGREES HELD

		ME	EE	CIE	Chem.	Met.	Other	Total	%
Group A	B.S.	118	107	60	24	14	8	331	86.2
	M.A.	7	13	9	2	17	0	48	12.5
	Ph.D.	0	0	3	0	2	0	5	1.3
Group B	B.S.	104	140	70	10	19	6	349	83.7
	M.A.	22	15	16	1	4	3	61	14.6
	Ph.D.	0	4	2	1	0	0	7	1.7
Group C	B.S.	35	59	52	2	8	2	158	77.5
	M.A.	6	7	7	1	20	1	42	20.6
	Ph.D.	0	2	0	0	1	1	4	1.9

	No.	%
Total B.S.	838	83.5
Total M.A.	151	15.0
Total Ph.D.	16	1.5
Grand Total	1,005	100.0

The Data

Number of Semesters of Drawing Taken:

A compilation of responses indicating the semesters of engineering drawing and descriptive geometry taken as an undergraduate shows that 422 or 42.0% of the respondents had taken two semesters of engineering drawing and one semester of descriptive geometry; 187 or 18.5% took one semester of each, and the others had varying combinations as shown in Table IV.

TABLE IV

SUMMARY OF NUMBER OF SEMESTERS OF ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY TAKEN BY RESPONDENTS

Semesters of Engineering Drawing Taken	Semesters of Descriptive Geometry Taken					
	0	1	2	More	Total	%
0	0	5	5	0	10	1.0
1	21	187	4	0	212	21.6
2	86	422	70	0	578	58.6
3	10	75	16	0	101	10.2
More	12	27	36	10	85	8.6
Total	129	716	131	10	986	100.0
%	13.1	72.6	13.3	1.0	100.0	

Semesters Engineering Drawing Recommended:

The responses to the question, "In the light of *your* experience, what would you consider to be the *minimum* amount of engineering drawing that a graduating engineer, entering your field, should have?" show that the majority of all engineers recommend that the undergraduate take two semesters of engineering drawing. In the case of the chemical, metallurgical and "other" engineers, however, the difference in percentages and the number of cases upon which the percentages are based makes the apparent difference between a one and a two semester recommendation insignificant. In the case of electrical engineers, the difference in total percentages for one and two semester responses is insignificant except that the difference for the 1954–1959 group is significantly in favor of a one semester course.

The response to question 4 was interpreted, therefore, as indicating that the mechanical and civil engineers should have two semesters of engineering drawing and that the other fields should have one.

Semesters of Descriptive Geometry Recommended:

The response to question 5, "In the light of your experience, what would you consider to be the minimum amount of descriptive geometry that a graduating engineer, entering your field, should have?" indicates one semester is recommended for all engineers. In this case the differences between year groups were not significant. The number of cases involved in the chemical and "other" groups makes the percentage differences insignificant for these groups.

Recommendations for One Semester Course:

Question 6 asked, "In the light of your experience, what is your reaction to a one semester combined course covering the essentials of orthographic drawing, sketching and descriptive geometry?" Those who indicated opposition to such a course outnumbered those in favor by almost a 2 to 1 ratio.

Course Content:

The course content of engineering drawing and descriptive geometry courses has often been questioned by individuals directly or indirectly concerned. The graduate engineers were asked their opinions concerning the various subject matter areas that are or could be covered in the curricula of different schools. The responses fall into three general categories: (1) should be included (2) neutral and (3) should be excluded. The respondents were given a choice of degree within these categories. The results of this phase of the questionnaire indicate that such controversial items as inking techniques, screw threads and spring representations should be eliminated from the engineering drawing courses. All other areas listed were considered to be a necessary part of the course or an area that should be included in either the engineering drawing or descriptive geometry courses. Many of the respondents, however, noted in their remarks that such areas as graphical integration and graphical differentiation could be covered more properly in other courses.

Graduates:

In reply to the question, "In your opinion, do the recent engineering graduates that you have had an opportunity to observe or work with, have a sufficient background in engineering graphics?," the respondents indicated that 35.9% of them were of the opinion that graduates had sufficient background to meet demands made; 15.2% felt that training was sufficient but lacking in certain areas, and 19.1% were of the opinion that graduates met the minimum requirements.

Conclusions

1. The majority of graduate mechanical (55.5%) and civil (48%) engineers are of the opinion that new graduates should have had two semesters of engineering drawing.

2. The majority of all engineering graduates is of the opinion that one semester of descriptive geometry should be a requirement for a graduating engineer.

3. The graduate electrical engineers are almost equally divided in their opinions concerning the question of whether one (39.5%) or two (43.5%) semesters of engineering drawing should be the minimum requirement for young engineers. The same holds true for metallurgical engineers, who divided 41.2% for one semester and 43.3% for a two semester requirement.

4. Inking techniques, screw threads and spring representations should, in the opinion of graduate engineers, be dropped from the engineering drawing curriculum.

5. Recent graduates, in the opinion of the respondents, are receiving a sufficient background in engineering graphics to meet the minimum demands made of them.

Remarks

1. This study reflects the opinions of only graduate engineers actively engaged in engineering work.

2. There were numerous remarks indicating that this type of study might well be conducted for other engineering courses within the curriculum.

3. The results of this type of study is

only one phase of a course evaluation and should not necessarily be the determining criteria.

4. Only 3.2% of the graduates were of the opinion that recent graduates had "more than enough" background in engineering graphics.

5. The returns were from graduates of 103 different colleges and universities; the greatest number of returns coming from graduates of University of Wisconsin (35%), Marquette University (18.4%), University of Illinois (4.5%), Purdue University (4.1%) and Iowa State, Illinois Institute of Technology, University of Michigan and the University of Minnesota.

Acknowledgments

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Candid Comments

This section is open to comments on articles in the JOURNAL or on engineering education in general. Send comments to the Editor, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

Deflection of Beams

In reply to Professor Spencer (April, 1961), I would note the following: It is true that at the time the original paper was written I was unaware of Maculay's note in *Messenger of Mathematics*. Further investigation shows that even this work was anticipated for essentially the same results are found in the once well-known book *Theorie der Elasticitat fester Korper*, published in 1862 by the German mathematician A. Clebsch. Mention should also be made of another paper which was unknown to me when "Deflection of Beams" was being prepared, namely, "Application of Maclaurin Series to the Analysis of Beams in Bending," *J. Franklin Institute*, Vol. 254, No. 5, 1952, by M. Hetenyi. In this paper, Professor Hetenyi shows all the details of calculations for continuous and discontinuous load functions. Had I been aware of this paper I should never have written in the first place, for it contains everything necessary to the solution of beam problems. Yet, I am glad I did write, because regardless of the origins of the method it is clearly the best way to solve beam problems and deserves a great deal more publicity and a wider acceptance.

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An Evaluation of the Overhead Projector in Teaching Kinematics

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The overhead projector has been used as a teaching aid for several years, in elementary education [1, 2] and in engineering drawing.[3] No use of an overhead projector in kinematics has been reported, nor has there been a statistical evaluation of its effectiveness in engineering education.

In the spring of 1959, the author taught two sections of kinematics. In one section, the lectures were written to include blackboard sketches and demonstrations; in the other section the lectures were written to include transparent overlays prepared for the overhead projector. Each transparent overlay presentation consisted of a step by step development of the lecture with one step on each of the transparent sheets. As the lecture progressed, the overlays were exposed to convey the pertinent information visually to the student.

The examination scores for two of the three units covered during the semester were compared by an analysis of covariance with the student's previous Engineering College average grade-point as the related variable. The results are as follows for a significance level of 5%:

Unit 1: Solutions of velocities on four-bar-linkages: no statistically significant difference between sections.

Unit 2: Solutions of accelerations on four-bar-linkages, including Coriolis Law: the scores for the section using the overhead projector were statistically significantly better.

Final examination over Units 1 and 2: The scores for the section using the overhead projector were statistically significantly better.

On the basis of these statistical tests, it is inferred that kinematics can be taught more satisfactorily by means of an overhead projector and prepared transparent overlays than by means of lectures based on blackboard presentations of the same material.

Statistical Development

The students in the two sections of kinematics taught during the spring semester, 1959, were considered to be random samples from a population of all students who have taken and will take this course. No systematic factors are known to bias this assumption. The students are also considered to be random samples from the two resulting treatment populations. One population consists of all students who were and will be taught kinematics by the author using lectures based on blackboard demonstrations; the other population consists of a similar group taught by the author using the overhead projector with prepared transparent overlays. The statistical results apply to these treatment populations.

The resulted variable used as the covariate in the analysis of covariance was the student's Engineering College average grade-point based on a minimum of 15 semester hours. The means and variances of the grade-point averages are:

	Overhead Projector Section	Blackboard Section	Totals
Means	2.34	2.46	2.40
Variance	0.17	0.32	0.24

The higher mean and greater variance in the blackboard section reflects a small group of extremely high grade-point students in that section. The students were all in their sophomore, junior, and senior years in the Mechanical and Electrical curricula. For the first examination, there were 29 men in the section taught

by blackboard lectures and 33 men in the section taught by use of the overhead projector. Attrition reduced these numbers to 28 and 31 respectively for the examination on the second unit and the final examination.

The hypothesis tested was: Among sophomore, junior, and senior students in the Mechanical and Electrical Engineering curricula at the State University of Iowa, the material covered in Kinematics, Units 1 and 2, can be taught as effectively by a lecture based on transparent overlays for an overhead projector as by a lecture based on the presentation of the same material with blackboard demonstrations.

A significance level of 5%, which is common for this type of analysis, was selected as providing an acceptable risk of Type I and Type II errors.

The statistical summaries are:

UNIT 1. SOLUTIONS OF VELOCITIES ON FOUR-BAR LINKAGES

Source	Degrees of Freedom	Σ Squares and Products			Errors of Estimate		
		Sx^2	Sy^2	Sxy	Σ Squares	df	ms
Total subjects	61	940.00	14.59	41.98	12.72	60	
Between sections	1	44.00	0.26	3.45	0.04	1	0.04
Within sections	60	895.13	14.33	38.53	12.68	59	0.215

$ms_{between}/ms_{within} = 0.186$ $\quad {}_{.05}F_{1,60} = 4.00$ not significant

UNIT 2. SOLUTIONS OF ACCELERATIONS ON FOUR-BAR LINKAGES

Source	Degrees of Freedom	Σ Squares and Products			Errors of Estimate		
		Sx^2	Sy^2	Sxy	Σ Squares	df	ms
Total subjects	58	549.22	14.22	40.75	14.15	57	
Between sections	1	1.38	0.20	0.52	3.08	1	3.08
Within sections	57	547.84	14.02	40.23	11.07	56	0.20

$ms_{between}/ms_{within} = 15.40$ $\quad {}_{.05}F_{1,56} = 4.02$ significant

FINAL EXAMINATION (GIVEN AT THE END OF THE SEMESTER)

Source	Degrees of Freedom	Σ Squares and Products			Errors of Estimate		
		Sx^2	Sy^2	Sxy	Σ Squares	df	ms
Total subjects	58	820.00	14.22	28.39	14.19	57	
Between sections	1	1.44	0.20	0.54	1.18	1	1.18
Within sections	57	818.56	14.02	27.85	13.01	56	0.23

$ms_{between}/ms_{within} = 5.08$ $\quad {}_{.05}F_{1,56} = 4.02$ significant

The examinations were also tested for reliability. The results are:

Examinations	Reliability
Examinations over Velocities (Unit 1)	0.723
Examinations over Accelerations (Unit 2)	0.899
Final Examinations	0.849

The conclusion reached is that for the hypothetical population from which these students are a random sample, higher criterion scores were obtained when the students were instructed by means of transparent overlays and an overhead projector than by means of blackboard demonstrations for the acceleration unit of the course and for the final examina-

tion. From this, it can be inferred that kinematics can be taught more effectively with the overhead projector.

The lack of a statistically significant difference between the scores for the first unit is attributed to the ability of the students to visualize and extrapolate the effects of the known velocities to other points on the bodies. Because of this, the method of presentation for velocities was not critical. On the other hand, accelerations cannot be visualized as easily, and the more effective method of presentation resulted in a higher set of criteria scores.

The author suggests that other courses might also be taught more effectively by using the overhead projector and prepared transparent overlays.

Teaching and Examination Procedure

The kinematics course is taught three times a week with each class consisting of approximately one-half hour lecture and over one hour of guided problem solving. This schedule was followed with both sections of the course. The primary difference was in the use of the overhead projector during the lecture portion.

The lecture for the overhead projector section was designed to utilize the transparent overlays to provide a framework for the lecture and show the progress of the lecture by exposure of successive overlays. Since kinematics is essentially the graphical solution of motion problems, the presentation involves trigonometry and graphical constructions. For any one lecture, the mathematical and graphical procedures were divided into four to eight major steps. Each step was placed on a separate sheet of acetate. As that step was reached in the lecture, the sheet was dropped onto the previous sheets and the lectures continued. By using two or more colors in the preparation of the transparencies, the new step can be easily located by the students. A grease pencil can be used to write marginal comments and to underline specific points that are particularly important. When the lecture is finished, the completed solution is before the student.

Questions raised during the lecture were answered immediately. The lecture was then restarted from the point at which the difficulty occurred. Because the transparent overlays can be removed, the solution proceeded without the interference of the later steps. Following the lecture, the remaining questions were answered in a similar manner. The students were encouraged to try to understand the lecture rather than to take notes. The transparent overlays were available during the problem-solving portion of the class period for those who wished to copy the steps into their notes or to refresh their memories by following through the steps at their leisure.

The transparent overlays were used to reduce the tutorial help necessary for students who continue to have difficulties and those students who miss a given lecture. The transparent overlays were also used as a basis for review periods since the basic material for the unit is in a collected form. Because the constructions are already prepared, the material can be reviewed faster and with more constructional accuracy than by working problems on the blackboard.

The other section received lectures in which the theory and problems were presented step by step on a blackboard. Questions were answered by tracing over existing lines, or by erasing part or all of the work and repeating the erased steps when this appeared necessary. Again, all questions were answered as they arose.

Both sections received essentially the same lectures. During the problem-solving portion of the course, a different teaching assistant was assigned to each of the sections.

The examinations consisted of 15, 12, and 11 problems, respectively, for the Units 1, Unit 2, and Final examinations. Each problem consisted of taking only the final one or two steps to a solution. The problems were designed so that the solutions were independent. All students took the same examination at a common time.

The tests were scored with two points for a correct solution and one point if there was a decimal or numerical error or a failure to indicate the sign on angular velocities and accelerations. Points

were not given unless a firm grasp of the principles involved was indicated.

Construction of the Overhead Projector Transparent Overlays

There are two methods of preparing transparent overlays. One is to transfer the information to the acetate sheets by means of a photographic process and the other is to work directly on the acetate sheet with a special plastic ink.

The State University of Iowa Audio-Visual Department suggested that the individual steps be prepared on separate sheets of tracing paper. These were used with a positive contact-type photographic technique to transfer the information to specially sensitized acetate sheets. Because the tracings can be easily prepared in India ink, this method has the advantage of ease of preparation. The choice of colors is determined by the sensitizing agent on the acetate sheet. The photographic preparation has the disadvantage of relatively high cost and that any variation in the opaqueness of the tracing paper will tend to result in reduced contrast between the desired information and the background. Further, the contrast may be reduced by exposure to sunlight, although artificial light has no effect.[3] If corrections or changes are desired, either a new sheet must be prepared, or corrections made using the second method.

The second method is to use a suitable plastic ink and a tank pen, such as the LeRoy lettering guide pen with a #00 point. As a number of colors are available, the author used red and blue for contrast between steps. This method of preparation has definite cost advantages if a lettering set is available. The contrast is maximum. Additions and corrections are easily made in the same manner. Mistakes can be "erased" by wiping them with ink thinner. Generally, greater skill is required to work directly on the acetate sheet than to work with India ink on tracing paper.

For this experiment, the image was projected against a standard screen. The author has since utilized a blackboard as a screen with equally good qualitative success. Blackboard images from the photographically prepared transparent overlays lack contrast without darkening the room for a class of approximately 40, but the directly prepared transparent overlays are excellent under these conditions. The projected area is usually reduced in the blackboard projection, which sometimes is a disadvantage.

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Ph.D. PROGRAM AT VANDERBILT

In September 1961, the Chemical Engineering Department at Vanderbilt University will initiate a graduate program at the doctorate level. Courses offered will include work in the areas of mathematics, transport phenomena, thermodynamics, kinetics, unit operations, systems analysis and design, and process control.

Current Philosophies and Instruction in Experimental Mechanical Engineering and Design Courses—A Selected Bibliography, Part II

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Teaching Aids

1 W. J. King, "Industry-College Cooperation in Developing Teaching Aids," *J. Eng. Educ.*, vol. 39, no. 2, pp. 90–94, 1948.

Reviews types of teaching aids and suggests bureau (say under ASEE) to collect and keep information and maintain liaison between industry and universities.

2 M. H. Lajoy, and O. M. Larsen, "A New Aid in Teaching Kinematics," *J. Eng. Educ.*, vol. 41, no. 9, pp. 542–3, 1950.

Describes models used for helping students to analyze an actual mechanism into a kinematic line diagram.

3 S. G. Lutz, "Exhibit of Teaching Aids at Seattle Meeting of ASEE," *J. Eng. Educ.*, vol. 41, pp. 406–8, 1950.

Lists aids exhibited. Included are: simple digital computer (Simon), quiz machine, can motion indicator, vibration models, plastic linkage models.

4 D. Rosenthal, and H. Baer, "Laboratory Demonstration Experiment—A Link between "Fundamentals" and "Applications," *J. Eng. Educ.*, vol. 41, pp. 171–5, 1950.

A way of making "fundamentals" live is to have demonstration experiment (e.g. "strength of materials" ideal) calculations related first to model experiment, then to test on actual machine. Pictures given.

5 J. Scheinman, "The Cam Motion Indicator—A New Teaching Aid," *J. Eng. Educ.*, vol. 41, pp. 111–114, 1950.

Apparatus draws follower displacement diagram. Illustrated.

6 R. S. Hartenburg, "Demonstration Models—Their Use and Construction," *J. Eng. Educ.*, vol. 40, no. 8, pp. 430–434, April, 1950.

Explains philosophy and technique of effective use of demonstration models. Illustrates models to show virtual work, angular momentum, magnus effect, and gives details of materials, etc. used for model making. Northwestern University.

7 M. M. Leven, "Photoelastic Stress Analysis Useful in Design of Metal Parts," *Materials and Methods*, vol. 33, no. 3, pp. 70–73, March, 1951.

Describes application of photoelasticity to two-dimensional stress

Interim Report on Project Supported by Grant from National Science Foundation.

problems. Excellent for description of inexpensive, easily-constructed diffusion-type polariscope.

8 "Turbine Training Aid," *Aeroplane*, vol. 80, no. 2070, pp. 356–7, March 23, 1951.

Portable system of models, cutaways, demonstrations, brochures, etc. of Rolls-Royce turbine equipment.

9 C. W. Muhlenbruch, "Judging the Effectiveness of Teaching Aids," *J. Eng. Educ.*, vol. 42, no. 3, November, 1951.

Discusses effectiveness of teaching aids, advantages and disadvantages. Aids should be carefully scrutinized for effectiveness, and should ask questions and stimulate student suggestions for producing aids. Ultimate aid mentioned is a "juke-box" which asks student questions, grades answers, records results, etc.

10 W. J. King, "Teaching Aids for Heat Transfer and Thermodynamics," *J. Eng. Educ.*, vol. 43, no. 3, pp. 167–170, November, 1952.

Some suggestions for teaching aids. Lists of models, films, charts, etc.

11 "Using Models in Design," *Product Engineering*, vol. 24, no. 9, p. 177, September, 1953.

Uses of models described and illustrated, showing: stress analysis, wind tunnel, flume, breadboards, appearance models, demonstrator models, clear plastic models, etc.

12 J. A. Hrones, "Role of Measurements and Instrumentation in Engineering Education," ASME Paper, no. 54 IRD-8 for meeting September 13–24, 1954.

Importance of engineering quantities and measurements. Instrumentation subjects should be integrated into existing courses rather than taught separately. Use of block diagrams and concept of closed loop and feedback should be introduced early. Suggests a travelling instrumentation exhibit be prepared by ISA and sent around to various engineering schools.

13 ASEE: "Educational Aids in Engineering," Brochure, March, 1955.

Prepared by a committee of ASEE, covers aids in civil, electrical, and mechanical engineering, mechanics, mathematics. Embraces films, filmstrips, diagrams, demonstration/laboratory equipment. In mechanical engineering, some interesting items are: Stodola's nozzle apparatus with exploring tube, epicyclic gear trains, fluid mechanics—films on smoke diffusion, wind curtains, turbulence, cavitation, flow phenomena (Prandtl) hydraulic demonstrator—closed conduit and open channel, magnus effect demonstrator. Introduction gives (among other things) useful criteria for judging and analyzing value of educational aids, and makes a plea for more attention to development of aids.

14 Roland W. Pinger, "Some Findings about Visual Aids in Engineering Education," *J. Eng. Educ.*, vol. 45, no. 8, pp. 652–3, April, 1955.

The author discusses the problems in using slides as visual aids. He claims that the aid is seldom worth showing unless home copy is furnished.

15 G. A. Taylor, "Importance of Visual Aids in Teaching of Advanced Radio and Electronic Engineering," *Inst. Radio Engrs. Journal*, vol. 16, no. 10, pp. 544–6, October, 1956.

Mentions charts, slides, films, demonstrations, "flannel graph," TV, etc. Gives list of films and film strips on radio in Great Britain.

16 G. Pask, "Automatic Teaching Techniques," *Brit. Communications and Electronics*, vol. 4, no. 4, pp. 210–11, April, 1957.

Description of machine and applications. System Research Ltd. and Solartron Electronic Grant Ltd.

17 E. Ferrari, "Plastics in New Product Design," *Plastics Technology*, vol. 3, no. 5, pp. 376–80, 382, May, 1957.

Methods and materials in model making and casting operations with plastics.

18 M. M. Leven, and A. M. Wahl, "Three-Dimensional Photoelasticity and Its Application in Machine Design," *ASME Transactions*, vol. 80, no. 8, pp. 1683–1691, 1958.
Describes simple test equipment (diffusion polariscope), model materials and techniques for three-dimensional photoelastic tests.

19 W. F. Seibert, "A Brief Report and Evaluation of Closed-Circuit Television Instruction in Mechanical Engineering," *J. Eng. Educ.*, vol. 48, no. 7, pp. 538–44, March, 1958.
Some conclusions: Student achievement was the same. Student response was good but disadvantages were evident—interest, inability to discuss questions, etc.

20 Simon Ramo, "A New Technique of Education," *IRE Transactions on Education*, vol. E-1, no. 2, pp. 37–42, June, 1958.
Visualizes future educational institutions in which all routine operations of teaching—dull memorizing, testing, grading, etc.—are done by machines, leaving only high level activity to teacher. Foresees a new profession, the "teaching engineer." Points out that proposals are expensive. Very stimulating.

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"Automatic" teaching device presents information and tests students in controlled feedback relationship. The author gives a general proposal for such a machine and points out advantages as well as limitations.

22 "Comprehensive Report on the Use of Instructional Television," Educational Television and Radio Center, 1610 Washtenan St., Ann Arbor, Michigan, July, 1958.
Price: $1.00.

23 R. C. Hill, "A Momentum Demonstration," *Heat Power News and Views*, vol. 14, no. 49, 1959.
Portable blower on platform suspended by wires. Blower discharges through measuring orifice. Movement of blower measures momentum change. Varying size of orifice shows some propulsion principles. University of Maine, Orono, Maine.

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Describes Pressey's machine of the 1920's and its limitations, then describes another machine being used at Harvard. Shows many advantages of the machine and relates them to modern psychology of learning.

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Description of the Solartron teaching machine which continuously adapts the teaching process to the progress of the learner. The machine described is one for training operators in punching cards. Made by Solartron Electronic Group, Thames Ditton, Surrey, England.

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Price: $4.50. Said to be the most comprehensive and authoritative reference work on automated instruction. It will bring together the basic papers by leaders in development of teaching machines and programmed exercises during the last four decades.

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The objectives of the course on control are mentioned along with some specific laboratory experiments including: "1. Difficulties encountered in steady state measurements including calibration of instruments. 2. Dynamic measurements a. Transient response, b. Frequency response. 3. Experimental determination of control system parameters from a. steady state data, b. transient response data, c. frequency response data. 4. Operation of a control system, comparing results with calculated responses." Includes some idea of description and cost of apparatus.

46 D. Rummer, "Teaching Aids for Laboratory Courses in Electrical Currents and Electronics," *Inst. Radio Engrs. Transactions on Education*, vol. E-1, no. 2, pp. 46–51, June, 1958.

Quick, adaptable system of chassis and banana jacks allows quick, easy assembly of diversity of circuits. Details given, but no pictures.

47 G. V. Edmonson, "The Fluids Engineering Laboratory at the University of Michigan," ASME Paper no. 59-HYD-16, 1959.

Describes the philosophy and planning of the above. Philosophy is that fluids engineering covers gases, liquids, solid suspensions in fluids, which together interest civil, chemical, mechanical and aeronautical engineers. Placing all together aims at cross-stimulation of the different fields. Maximum versatility in equipment and minimum fixed machinery are features. Space flexibility is sought by such devices as portable enclosures which can be set around a project, then removed on completion.

48 R. C. Hill, "A Momentum Demonstration," *Heat Power News and Views*, vol. 14, no. 49, 1959.

Portable blower on platform suspended by wires. Blower discharges through measuring orifice. Movement of blower measures momentum change. Varying size of orifice shows some propulsion principles. University of Maine, Orono, Maine.

49 "Jason Reactor for Training and Research," *Engineer*, vol. 207, no. 5385, pp. 582–4, April 10, 1959.

Describes 10-KW reactor built from "Argonaut" design.

50 "Cheap Wind Tunnel Models from Plastic Kits," *Space/Aeronautics*, vol. 31, no. 59, p. 99, May, 1959.

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51 W. A. Blackwell, and H. E. Koenig, "A Combined Machinery and Control Systems Laboratory," *Inst. Radio Engrs. Transactions on Education*, vol. E-2, no. 4, pp. 128–134, September, 1959.

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when you want to measure flow by means of a differential pressure drop."

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56 R. S. Hartenberg, and J. Denavit, "The Kinematics Laboratory at Northwestern University," *Machine Design and Manufacturing Bulletin*, a publication of the Mech. Eng. Division of ASEE, vol. 26, no. 3, February, 1960.

The authors state that the initial purpose was to explain the basic concepts of the geometry of motion in its multiple aspects as during successive displacements of a mechanism. Gradually the utility of the laboratory was increased to include areas where visual data and physical impressions support abstractions. The result is worthy of close study by all teachers of kinematics, since it is an outstanding achievement.

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59 W. C. Reynolds, "Demonstration Experiment for Heat Transfer," Stanford University, unpublished, undated.

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69 C. O. Mackey, and N. R. Gay, "Cooling Loads from Sunlight Glass and Wall," Presented at Semi-Annual Meeting, The American Society of Heating and Ventilating Engineers, Swampscott, Massachusetts, June, 1954.

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73 Howard C. Roberts, *Mechanical Measurements by Electrical Methods*, The Instruments Publishing Co., Inc., Pittsburgh, 2nd Ed., 1951.

74 P. K. Stein, "Measurement Engineering, Science or Technology?" *Strain Gage Readings*, vol. II, no. 6, Feb.–Mar., 1960, Stein Engineering Services, Phoenix, Arizona.

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76 S.E.S.A., *Manual on Experimental Stress Analysis Techniques*, (Prelim. Edit.), Society for Experimental Stress Analysis, Cambridge, Massachusetts, 1959.

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5 R. J. Sweeney, *Measurement Techniques in Mechanical Engineering*, John Wiley and Sons, New York, 1953.

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9 H. F. Dodge, "Interpretation of Engineering Data: Some Observations," Edgar Marburg Lecture presented before 57th Annual Meeting of the American Society for Testing Materials, 1954.

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14 D. J. Finney, *Experimental Design and Its Statistical Basis*, The University of Chicago Press, 1955.

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15 Owen L. Davies, *Statistical Methods in Research and Production*, 3rd Ed., Hofner Publishing Co., New York, 1956.

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A layman's introduction to statistics available in a paper-back. A comprehensive introduction to the possibilities of the subject. Book ranges from purely descriptive statistics through probability theory, design of sampling schemes, production quality control, correlation, analysis of variance and co-variance. Highly recommended, particularly to the reader who has not had formal training in the subject of probability and statistics. Clearly written in an entertaining style.

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20 N. G. Parke, III, *Guide to the Literature of Mathematics and Physics Including Related Works on Engineering Science*, Dover Publications, New York, 1958.

Sections on design of experiments, measuring, apparatus, etc. Excellent references with comments. Advice on the conduct of literature searches.

21 J. S. McNown, and H. Orel, "Experiments and Reports on Turbulent Mixing, Etc.", *Kansas Engineer*, Lawrence, Kansas, pp. 13–17, January, 1959.

Shows how small projects instead of routine tests transform lab work from uninteresting routine to valuable and stimulating instruction. Report-writing greatly improved since student has a well-defined audience and a specific message. Four projects mentioned are: 1. Study of entrainment of air by jet of liquid entering liquid. 2. Detection of position of leak in pipe by reflection of pressure wave. 3. Deflection of a stream of water by partial obstruction. 4. Study of emptying time of bottles.

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Notes written for a course intended to provide beginning engineering students an introduction to the general procedure for studying the behavior of engineering systems. First section outlines course content, second deals with measurements and descriptive statistics. Sections three, four and five describe experiments to be performed. Sixth section contains selected reading list. Section on measurements and statistics extremely interesting and important for early introduction of important concept.

23 L. Trefethan, "Information Concepts and Laboratory Work at Tufts University," June, 1960.

A radically new approach to the whole curriculum, making information concepts the touch-stone and basis of everything. Laboratory becomes place for gathering and studying information. All faculty members participate in lab in areas where they are interested. Amount and kind of lab work by student depends on individual faculty members. Endeavors are made to carry on projects.

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26 J. C. Boonshaft, "Measurement Errors: Classification and Interpretation," ASME Paper N-53-A-219 for meeting November 29–December 4, 1953, 6 pages.

Classification and appearance of errors contributing to uncertainty of measurement with industrial indicating and recording instruments.

Teaching Positions Available (*Continued from page 799*)

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Transfers to Schools or Colleges of Engineering 1951, 1952, 1953, 1959, and 1960

HENRY H. ARMSBY

Chief for Engineering Education
Division of Higher Education
U. S. Office of Education

This circular presents the results of the fifth study of transfers to schools or colleges of engineering. Earlier studies were conducted during the years 1951, 1952, 1953, and 1959 under the joint auspices of the American Society for Engineering Education and the U. S. Office of Education. In the first three of these surveys the engineering colleges were asked to report the number of students "now classified" as first, second, third, or fourth year students who in the fall of the year in question entered the engineering college by transfer (a) from curriculums leading to engineering degrees, and (b) from curriculums not leading to engineering degrees. The number of such students reported for each class was converted for each institution to a percentage of total enrollment in that class. These percentages, rather than the actual numbers involved, were used in the preparation of tables contained in the three original reports and in Circular No. 397, dated April 1954, which summarized the three reports. Circular 397 is out of print, but its data on transfers from non-engineering curriculums are included in this circular.

The series of surveys was renewed in 1959 because of the belief that there had been a material expansion in the numbers of transfer students since 1953, and that this expansion might account for an appreciable fraction of the decline in engineering freshman enrollment which had taken place during the preceding 2 years. This feeling was shared by many of the deans of engineering colleges, and at about the time the decision was made to conduct the survey a formal request was received by the Office from the General Council of the American Society for Engineering Education asking that the earlier study be reactivated.

For the purposes of these reactivated studies it is considered that the transfers from one engineering college to another are unimportant, since they do not change the number of students enrolled in engineering curriculums. Hence, while to a particular institution they may constitute a serious problem, from the national manpower aspect they are considered to be immaterial.

The current questionnaire therefore covered transfers to engineering colleges in the fall of 1960, but only from non-engineering curriculums. Instructions stated that the students reported "should include transfers from liberal arts colleges (in your own or another institution), junior colleges, community colleges, technical institutes, etc., but should not include transfers from degree-granting engineering colleges."

The questionnaires were mailed to the deans of engineering at the same time that blanks for the engineering enrollment reports were sent to the registrars. Subsequent follow-up mailings resulted in an almost complete coverage of the engineering colleges.

Usable replies were received from 227 engineering colleges, which represent 96.1% of the recognized degree-granting

Statistical tabulations and computations by Shirley Radcliffe, Research Assistant, Division of Higher Education. This article is a reprint of U. S. Department of Health, Education, and Welfare, U. S. Office of Education Circular OE-54005-61, March, 1961.

TABLE 1

ANALYSIS OF RESPONDENTS

Item	1951	1952	1953	1959	1960
Number of engineering colleges to which questionnaires were sent	192	193	210	231	236
Number of usable replies received	156	163	185	160	227
Percentage of response	81	85	88	69	96
Engineering students in first, second, third, and fourth years of respondent institutions as percentage of such students in all U. S. engineering colleges	84	73	95	76	96

engineering schools in the United States. The responding institutions in the fall of 1960 enrolled 96.0% of all first-year engineering students, 95.6% of all second-year engineering students, 96.5% of all third-year engineering students, 96.4% of all fourth-year engineering students, and 96.2% of engineering students in the four classes combined. Data from individual schools can be supplied on request.

These figures indicate that the respondents constitute a consistent sampling of all the engineering colleges, and that it is safe to consider that the percentages presented in this bulletin are representative of all engineering colleges in the country.

Table 1 shows comparative analyses of the groups of institutions reported in this survey and those in previous years.

As in the earlier studies, the number of transfer students reported for each class in an institution was converted into a percentage of the total enrollment in that class as reported by the institution in the regular fall engineering enrollment report. These percentages, rather than the actual numbers involved, were used in the preparation of Tables 2 and 3. In these tables the data for 1951, 1952, 1953, and 1959 are taken directly from similar tables in the earlier reports.

Since many institutions find it difficult to report the exact number of students transferring into the institution from non-engineering curriculums, the deans were asked to make their best estimate of the numbers of such students if they were unable to supply definite figures. The percentages shown in Table 2 and in Table 3 are based on the total numbers reported by the institutions, and therefore represent a combination of estimates and actual enrollment data.

The institutions which on the 1960 questionnaire submitted estimates rather than exact numbers were: for first-year students, 22%; for second-year students, 21.4%; for third-year students 17.4%; for fourth-year students, 13.9%.

Table 2 shows for the years 1951, 1952, 1953, 1959, and 1960 the maximum percentage of each class reported by any one institution as having been admitted by transfer from a non-engineering curriculum, the weighted average of the percentages so admitted, the median percentage, and the minimum percentage. The last figure is zero for all class levels in every year.

A review of the individual reports from the institutions discloses that there was a wide range among institutions in the proportions of their students who had been admitted by transfer, especially during the first three years. The large differences between averages and medians are due to the fact that in a small number of institutions the percentages of transfer students are far higher than the average for the group.

The figures quoted as maximum percentages apply in every instance to one institution, and in practically all categories there is a large drop between this institution and the next larger.

Table 3 gives distributions of instructions according to the percentages of their various classes who were admitted by transfer from non-engineering curriculums during the years listed. Columns 3 to 6, inclusive, show for each year the percentage of institutions which admitted

the percentage of transfer students indicated in column 1. For example, in 1960 44.0% of the institutions admitted between 0.1% and 4.9% of their first-year students by transfer from non-engineering curriculums. This represents a decrease of 1.1% from the corresponding figure for 1959, during which year 45.1% of the institutions admitted this percentage of first-year students by transfer.

The data contained in Tables 2 and 3 demonstrate without question that there has been a considerable increase since 1951 in the numbers and percentages of students admitted to engineering colleges by transfer from non-engineering curriculums. At each class level there has been a decided drop in the number of institutions which admitted *no* such students, and there have been increases in nearly all of the percentages for the various groups covered in Table 3. There have also been at each class level increases in the maximum percentage admitted, in the weighted average, and in the median percentage. It is quite apparent, therefore, that the problem of the transfer student is growing rapidly in seriousness to the engineering colleges.

As to the relationship between the increases in transfer students and the decline in engineering freshman enrollments, it is unfortunate that this series of studies was discontinued during the years between 1953 and 1959, since it is impossible to get a direct comparison between the figures for 1959 and the corresponding ones for 1958 and 1957.

However, a comparison of the figures for 1959 and 1960 with those for the years 1951, 1952, and 1953 indicate quite clearly that there is such a relationship and that the increase in transfer students has been a contributing factor in the decline of freshman engineering enrollments. The first-year students admitted by transfer in the fall of an academic year represent students who were enrolled in a non-engineering curriculum for one or two semesters, usually in the preceding academic year, and who then transferred to the engineering college,

TABLE 2

PERCENTAGE OF STUDENTS TRANSFERRING TO ENGINEERING COLLEGES FROM NON-ENGINEERING CURRICULUMS BY CLASS LEVEL, FALL OF 1951, 1952, 1953, 1959, AND 1960

Item	Year	Class Level			
		1st year	2d year	3d year	4th year
(1)	(2)	(3)	(4)	(5)	(6)
Maximum	1951	29.7	46.7	41.7	10.7
	1952	23.6	31.7	30.8	6.3
	1953	50.0	50.0	56.2	34.3
	1959	88.0	100.0	66.0	91.3
	1960	93.5	74.4	100.0	83.6
Weighted average	1951	3.7	5.8	3.8	0.3
	1952	3.4	6.0	3.7	0.4
	1953	2.8	4.0	3.3	0.5
	1959	5.0	8.5	7.5	1.5
	1960	4.4	9.2	9.9	1.1
Median	1951	2.1	4.0	0.9	0.0
	1952	1.8	3.8	0.7	0.0
	1953	1.0	2.2	0.0	0.0
	1959	2.9	5.6	3.3	0.0
	1960	3.0	5.7	2.4	0.0
Minimum	All Years	0.0	0.0	0.0	0.0

TABLE 3

PERCENTAGE DISTRIBUTION OF ENGINEERING COLLEGES ACCORDING TO THE PERCENTAGE OF TRANSFER STUDENTS FROM NON-ENGINEERING CURRICULUMS BY CLASS LEVEL, FALL OF 1951, 1952, 1953, 1959, AND 1960

Transfers as Per Cent of Class	Year	Percentage of Colleges			
		1st Year	2d Year	3d Year	4th Year
(1)	(2)	(3)	(4)	(5)	(6)
0	1951	34.7	26.3	43.6	84.5
	1952	31.3	24.5	48.5	82.8
	1953	42.2	35.2	54.2	81.7
	1959	23.5	16.7	26.0	69.7
	1960	23.9	13.7	30.9	64.9
0.1 to 4.9	1951	39.6	30.1	33.3	14.1
	1952	39.2	30.1	28.3	14.7
	1953	37.3	34.5	26.3	13.5
	1959	45.1	30.2	36.4	22.2
	1960	44.0	30.1	28.3	27.0
5.0 to 9.9	1951	14.2	26.9	10.9	0.7
	1952	17.2	24.5	9.8	2.5
	1953	13.5	17.3	10.8	1.6
	1959	18.5	24.7	19.1	3.1
	1960	19.6	22.4	16.1	4.5
10.0 to 19.9	1951	8.3	9.6	8.4	0.7
	1952	10.5	13.6	11.6	0.0
	1953	6.0	10.3	4.9	2.1
	1959	8.6	20.4	10.5	2.5
	1960	9.1	21.0	9.0	0.9
20 or more	1951	3.2	7.1	3.8	0.0
	1952	1.8	7.3	1.8	0.0
	1953	1.0	2.7	3.8	1.1
	1959	4.3	8.0	8.0	2.5
	1960	3.4	12.8	15.7	2.7

but did not receive sufficient credit to be classified as sophomores. Therefore, from the standpoint of engineering these represent students who postponed their entrance to an engineering college for one year. In other words, these students could have entered the engineering college in the previous year, but for one reason or another did not do so.

Similarly, the second-year students who are admitted by transfer in the fall of one academic year represent students who have been enrolled in a non-engineering curriculum for two years, and who therefore might have entered engineering school two years earlier, and might now be third-year students. From the standpoint of engineering education these students postponed their college entrance for two years.

Students have been transferring from non-engineering curriculums to engineering colleges for many years, and if their numbers remained constant the "loss" of engineering freshmen in a given year would be offset by the "gain" on transfers from the preceding year, resulting in no net change. But when the number of transfer students increases in one year over the preceding year, the increment results in a corresponding decline in engineering freshmen in the second year.

Similarly, a decline in the number of transfer students in one year will result in an increase in engineering freshmen the following year, as is illustrated by the increases in engineering freshmen which followed the declining percentages of transfer students shown in Table 2 for 1952 and 1953.

It does not seem worth while to carry out any elaborate mathematical computation in an attempt to arrive at an exact fraction of the engineering freshman enrollment drop which can be attributed to the increase in transfer students, but it is obvious that there is a direct connection.

Such a computation might be made by applying the change in the weighted average from one year to the next to the total engineering freshmen in the second year, which would give a figure for the total number of transfers, which could in turn be converted to a percentage of the total increase or decrease of engineering freshmen. In OE-54005, the study similar to this one which was issued in March 1960, such a computation was followed through on the basis of two estimates for the missing figures for the year 1958 (JOURNAL, June, 1960, pp. 869–873). These estimates were based upon two assumptions, (1) that the increase from 1953 to 1959 took place uniformly through the six years, and (2) that the entire change took place between 1958 and 1959. Under the first assumption the computation indicated that the increase in transfer students from 1958 to 1959 accounted for about 11½% of the decrease in freshman enrollment. Under the second assumption it would account for 61½% of the decrease. Similarly, the increases in second-year transfers would account for somewhere between 6½% and 30½% of the decline in sophomore enrollment. It was pointed out in that bulletin that these extremely wide ranges in possible values furnish an excellent example of the importance of continuity in statistical studies in any field of education. If the study of transfers had been continued through the years between 1953 and 1959 the resulting data would make possible a much more reliable measure of the relationship between transfer students and freshman enrollments.

Using the data collected in 1960 in comparison with that for 1959 by the same method of computation outlined above would indicate that the freshman enrollment in 1960 should have exceeded that for 1959 by about 400 students, whereas actually there were 148 fewer freshmen in the fall of 1960 than in the fall of 1959. At the sophomore level the increase in the weighted average of transfers applied to the total number of second-year students would indicate that the increase in transfers from 1959 to 1960 would account for 25% of the decrease in enrollment. At the third-year level the increase in the weighted average of transfers applied to the 1960 enrollment would account for about 27% of the decline in third-year enrollments.

The lack of information for the years 1954 to 1958, inclusive, makes it extremely difficult to arrive at any sound and logical conclusions as to general trends in the percentage of students transferring into engineering curriculums. Freshman engineering enrollment reached its post-war low in 1950, and its all-time high in 1957. The corresponding low and high points for other classes were, second-year students 1951 and 1957, third-year students 1952 and 1957, fourth-year students 1953 and 1958.

The enrollment in all classes has been declining steadily since the high points noted above were achieved. Since all the high points occurred during the years in which no statistics on transfers were collected, it is impossible to tell with any accuracy whether or not the turning points in enrollments could have been predicted, had data on transfers been available. In other words, the peaks in transfers may have occurred before or after the high points in enrollments; and the size of the transfer group may be more or less than the increase or decrease in freshman enrollments. This points up the importance of continuity and the difficulty of attempting to project ahead on the basis of the partial information at hand.

It seems certain that there is a relationship between changes in percentages

of transfer students and declining or increasing enrollments, but it is quite obvious that it will be necessary to continue this study for a few more years if reliable and logical trends are to be determined.

It might be pointed out that there has also been a growth in the number of "3–2" programs, in which engineering colleges cooperate with liberal arts colleges in the offering of 5-year curriculums leading to degrees both in liberal arts and engineering . This development increases the number of students transferring from non-engineering curriculums to engineering colleges, principally at the third-year level.

When it is remembered that 86% of the engineering colleges which responded to the 1960 questionnaire admitted second-year students by transfer from non-engineering curriculums, that 76% admitted first-year students by this method, 69% admitted third-year students, and 35% admitted fourth-year students, it becomes evident that the problem of transfer students is important in a significant proportion of the engineering colleges of the country.

What's Going On In ASEE

A Narration of Major Actions of the Executive Board, April 7, 1961

W. Leighton Collins, Secretary

A number of changes having a far-reaching impact on ASEE and its functioning were initiated at the April meeting of the Executive Board. The long-standing problem of active membership for technical institutes, individual memberships for the representatives of industrial members, a revision of the dues structure to insure adequate financing for the foreseeable future, and a change in the election procedure for active members were the major actions taken. All decisions were motivated by the desire to continue to improve the services of the Society to all categories of membership and to insure that ASEE continues to be the spokesman for engineering education in the United States.

The position of the technical institute and the adequate financing of the Technical Institute Division is a long-standing problem and one becoming more complicated by the fact that in some states the technical institutes are integral parts of the state universities which are active members of ASEE. It was voted that technical institutes having one or more technical institute curricula accredited by the Engineers' Council for Professional Development be eligible for active membership, and that the representatives of such institutions be recognized as a Technical Institute Council, just as the Engineering College Administrative Council consists of representatives of member institutions having one or more baccalaureate curricula in engineering accredited by ECPD. Under this new arrangement an active member might be eligible for membership in one, two, or three councils–ECAC, ECRC, or TIC.

A real budget problem is introduced because with this elevation of technical institutes to active membership the established practice of the Technical Institute Division to collect voluntary contributions of $4.00 per year from interested individual members is to be discontinued. The nominal contributions from the Society were totally inadequate to meet the Division's needs, and that is why this extra source of funds was sought.

The dues of all categories of institutional members have not been changed since 1946. Considering the increased costs of everything since that date, that services to members have improved, that the Society is more active now than ever before (judged by the special studies of recent years, if nothing else), that dues of individual members have been increased in the meantime, and that an

analysis of direct services rendered shows some great imbalances, the only conclusion possible is that the current dues structure of institutional members is archaic. To keep pace with developments, a revision actually should have been initiated years ago. But as long as growth alone provided increased income of sufficient magnitude to permit some improvements, the burden of dues increases was placed entirely on the individual members.

In order to realistically face the future and to insure a sound financial structure for the years immediately ahead, it was voted that the dues for active institutional members be $75 per year for participation in any one council, plus an additional $25 per year for participation in each additional council. Changes also are recommended for the other types of institutional memberships. Some comparisons follow.

Active Members	Present	Recommended
Participation in ECAC only	$35	$ 75
Participation in ECAC and ECRC	50	100
Participation in TIC only	25[1]	75
Participation in ECAC and TIC	60[2]	100
Participation in ECAC, ECRC, and TIC	75[2]	125
Associate members	$50	$75
Industrial members	50	75
Affiliate members	25	35

[1] Affiliate membership.
[2] Active and Affiliate memberships required.

Based on the present membership, the estimated additional annual income will be about $14,000, which is only about 9.7% of the current operating budget. The difficulty, however, is that the provisions of the constitution and bylaws of the Society make it essentially impossible to make the changes effective prior to July 1, 1962.

Whenever the participation of industry in the Society has been discussed the big question always has been how the representatives of industrial members find ways and means of participating; they have never belonged to anything as individuals. To remedy this situation and to thus make it easier to get new members and hold the ones we now have, it was voted that each industrial member have the right to designate one representative who automatically becomes an individual member of the Society with all rights and privileges without having to pay additional dues. The Relations With Industry Division and the Industrial Membership Committee both have urged that this change be adopted so that the representatives have a "divisional home" like individual members now enjoy. This change might result in some loss of income because some representatives now hold individual memberships and probably will discontinue them.

The budget for 1961–62 has been given the most extensive preliminary study of any budget in recent years. The reason is that it cannot be balanced and still maintain the sound financing policies of recent years, and particularly so if the initiated and contemplated improvements in services are to be carried out. From previous actions of the General Council and Executive Board improvements in services rendered by the Society are:

1. Editing and distribution of the *Research Review*.
2. Coordination of all Society publications, particularly the newsletters of divisions. This program is still in the planning stage, but involves such things as more adequate financing, improvement of quality, and the providing of Divisional mailing lists for improved distribution.
3. Mailing lists for members of Sections and department heads.
4. Quality of publications.
5. Doubling the number of major awards.
6. The Industrial Fellowship program.
7. The Position Wanted section in the *Journal of Engineering Education*.
8. The Divisional listing of members in the Yearbook-Directory.
9. Cooperation with the education committees of professional engineering societies.

Certain services not required five or more years ago now also must be provided by the Society, such as:

1. Distribution of publications. Five years ago, other than the *Journal of Engineering Education* and the *Proceedings*, there were four special reports or publications. Now there are about 20!
2. Special Studies. The number has been gradually increasing and it looks as though the trend will continue. Each of these, even when carried on at a particular institution, involves time and effort at Society headquarters and results in benefits to members.
3. *Journal of Engineering Education.* Ten years ago the number of pages per year was 500 to 600; now the total is between 900 and 1,000. This increase is also accompanied by an increase in quality of papers; only about 1 of 5 or 6 papers submitted for publication can be printed.

But getting back to the budget for 1961–62, the first draft showed a deficit of about $17,000. Continued study and whittling finally reduced it to about $7,000, the major reductions resulting from the deletion of an allocation to the emergency reserve, the deletion of an added employee in Society headquarters, a higher estimate of indirect cost recoveries from special projects, and a generous estimate of the continued growth of all categories of membership, particularly affiliate, where a strong effort is being made to interest junior colleges offering the so-called "pre-engineering" curricula.

To avoid deficit financing for 1961–62 and to maintain a reasonable balance in the per cent increase in dues since 1946, it was voted to recommend to the General Council that the dues of individual members 36 years of age and over be increased from $9.00 to $10.00 per year, effective July 1, 1961. It is estimated that this will increase the income some $5,500 per year, or about 3.8 per cent. This increase will bring the dues of all individual members to the maximum permitted by the constitution.

These are the actions which seemed to be necessary for ASEE to be a strong, vigorous Society, the spokesman for engineering education, and the leader to which individuals, other societies, national and international, governmental agencies, etc. will naturally look for consultation and guidance. Each major group directly involved in the changes will be consulted and approval of all groups is sought. The whole-hearted support of each member is solicited.

HUMPHREYS APPOINTED PRESIDENT OF COOPER UNION

The appointment of Dr. Richard Franklin Humphreys as president of The Cooper Union for the Advancement of Science and Art in New York City has been announced by Irving S. Olds, chairman of the Cooper Union trustees. A leading scientist in the nuclear field, Dr. Humphreys is now vice president of Armour Research Foundation of the Illinois Institute of Technology, Chicago.

Dr. Humphreys succeeds Dr. Edwin S. Burdell as head of the 101-year-old Cooper Union, which is the nation's oldest tuition-free private college of engineering, art, and architecture. Dr. Burdell retired in February, 1960, to become president of the Middle East Technical University in Ankara, Turkey, after 22 years as director and president of The Cooper Union.

Dr. Humphreys will assume his new position on June 1, 1961.

Dr. Humphreys has served as acting director of the Sloan Physics Laboratory at Yale and also as consultant on underwater sound research for industry and the government. He is co-author of a textbook on "First Principles of Atomic Physics," and has published papers in Physical Review, Review of Scientific Instruments, and numerous other scientific journals.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny		April, 1961	E. R. Schatz, Carnegie Institute of Technology
Illinois-Indiana	Ill. Inst. of Tech.	May 13, 1961	Peter Chiarulli, Ill. Inst. of Tech.
Kansas-Nebraska	Kansas State U.	Oct. 27–28, 1961	M. H. Snyder, Univ. of Wichita
Michigan	Michigan State U.	April 22, 1961	C. E. Cutts, Mich. State Univ.
Middle Atlantic	Columbia Univ.	Dec., 1961	F. L. Singer, New York Univ.
Missouri-Arkansas	Univ. of Ark.	April, 1962	J. L. Imhoff, Univ. of Arkansas
National Capital Area		Jan. 10, 1961	Geo. H. Hickox, Ft. Belvoir, Va.
New England	Brown University	Oct. 13–14, 1961	E. F. Littleton, Tufts Univ.
North Midwest	Mich. Coll. of Min. & Tech.	Oct. 6–7, 1961	C. E. Work, M.C.M.T.
Ohio	Ohio State Univ.	May 6, 1961	R. S. Green, Ohio State Univ.
Pacific Northwest	Univ. of Washington	May 5–6, 1961	H. P. Mittet, Univ. of Washington
Pacific Southwest	Las Vegas, Nev.	Dec. 27–28, 1961	R. J. Parden, U. of Santa Clara
Rocky Mountain	University of Wyoming	Apr. 28–29, 1961	A. J. McGaw, Univ. of Wyoming
Southeastern	Univ of Mississippi	April 20–21, 1961	W. J. Seeley, Duke Univ.
Southwest	Univ. of Tulsa	Apr. 7–8, 1961	G. B. Tims, Jr., Lamar State College
Upper N. Y.-Ontario	Clarkson College	Oct. 6–7, 1961	R. D. Larsson, Clarkson College

Mid-Winter Meetings–1962

Cooperative Education — Jan. 23–25 — University of Detroit

Information: D. C. Hunt, Director of Coordination and Placement, University of Detroit, Detroit, Mich.

Engineering Graphics — Jan. 1962 — University of Wisconsin

K. G. Shiels, Assistant Dean of Engineering, Univ. of Wisconsin, Madison, Wisc.

College-Industry Conference — Worcester Polytechnic Institute

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VISITING ENGINEERS PROGRAM

ASEE's Visiting Engineers Program, inaugurated in the spring of 1960, has received support from the National Science Foundation to continue through August, 1962. The NSF grant totals $24,700 for the period of support.

Under this program, prominent engineering educators visit colleges, junior colleges, and new colleges of engineering, giving talks to student groups and holding discussion sessions with interested faculty and students. Sixty visits have already been made under NSF support in this program. The program will be administered by ASEE Headquarters under direct supervision of J. W. Seyler, Assistant Secretary of the Society. This study is expected to do for technical institute education what the "Report on Evaluation of Engineering Education" did for baccalaureate degree programs.

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